University Of Babylon
Colege Of Dentistry

Imaging of Salivary Glands

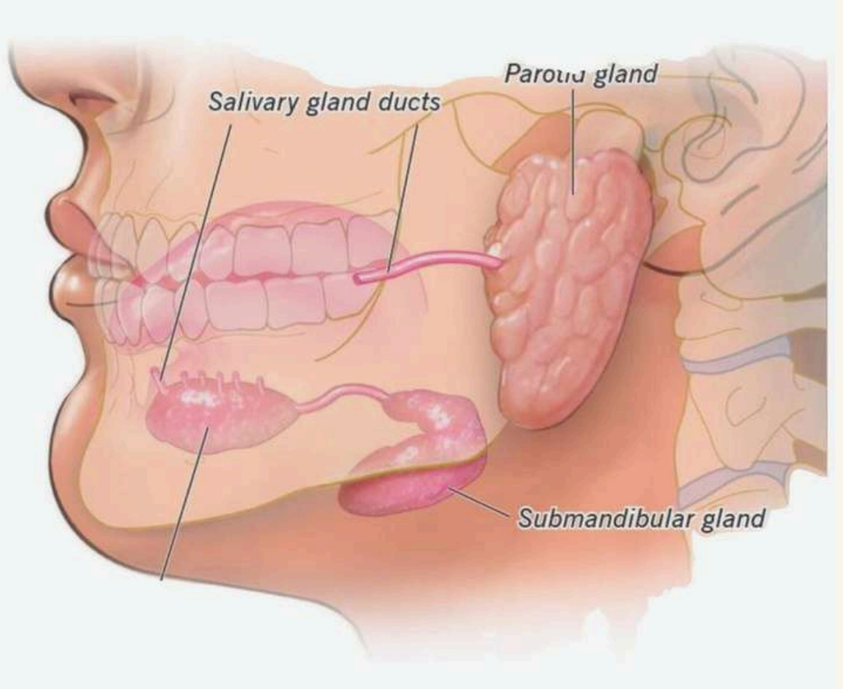
By:
Anwer Sabah
Hussein Abbas Ibrahim
Mariam Noori
Eman Ahmed
Safa Asaad

Supervised by:
Dr.Ali Zaki
Dr. Aymen Hameed

Introduction

The salivary glands are exocrine glands that make, modify and secrete saliva into the oral cavity. They are divided into two main types: the major salivary glands, which include the paro tid, submandibular and sublingual glands, and the minor salivary glands, which line the mucosa of the upper aerodigestive tract and the overwhelming entirety of the mouth

.



Salivary glands play an important role in digestion because they make
saliva. Saliva helps moisten food so we can swallow it more easily. It also has an enzyme called amylase that makes it easier for the stomach to break down starches in food

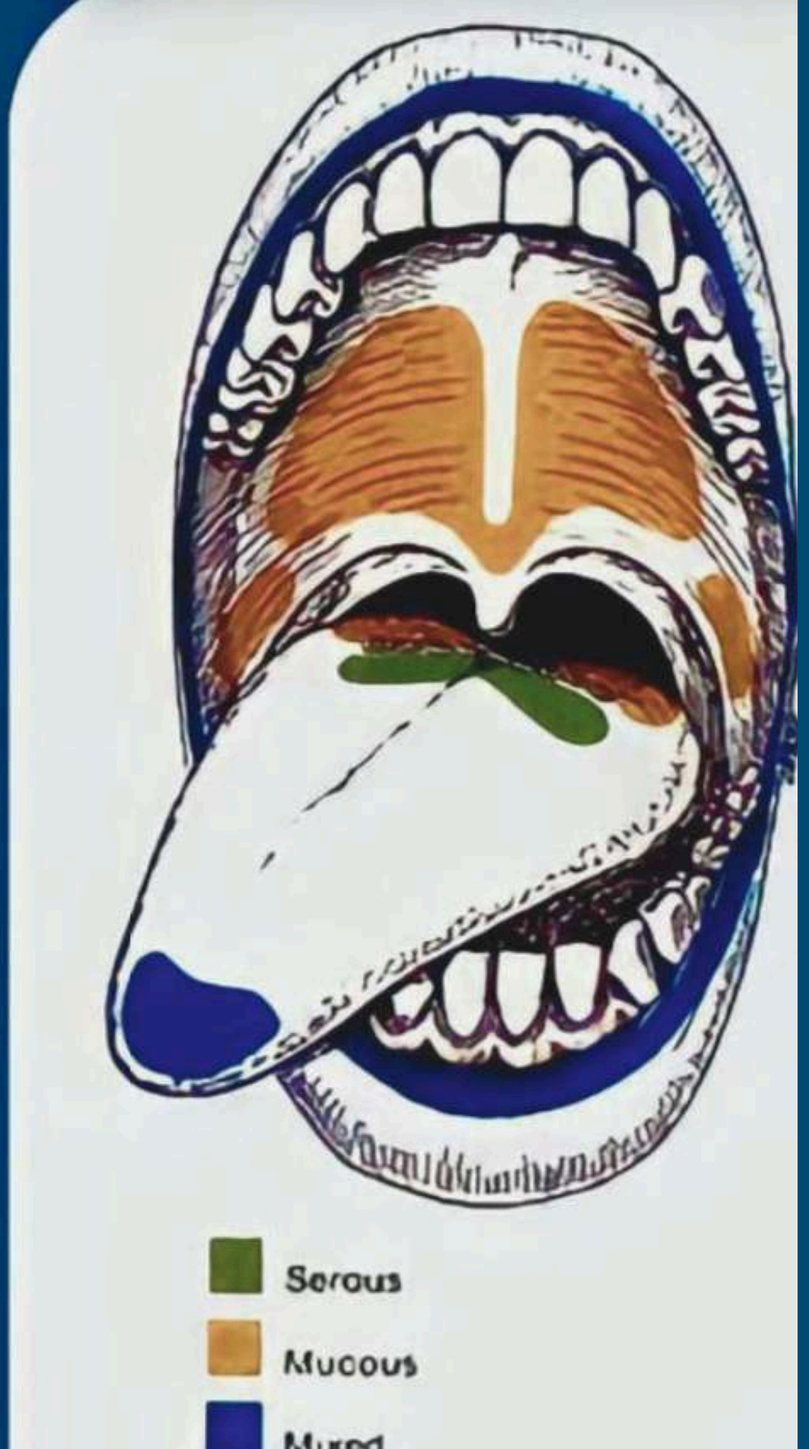
The parotid gland (PG) is mainly composed of serous acini-secreting a- amylase-rich saliva (Dobrosielski-Vergona et al., 1993). The sublingual gland (SL) secretes mucous, a viscous solution rich in mucins (Korsrud et al.,1980). The submandibular gland (SMG) is composed by a mixed population of acini with a mucous and serous function (Smith et al., 1987). These three major salivary glands account for more than 90% of salivary secretion.

Minor salivary glands are distributed throughout the oral cavity, specically in
the labial and lingual mucosa, as well as palate and floor of the mouth.

Anatomy:

- **Minor salivary Glands**
- Labial (lips) – mixed
- Buccal (cheeks) - mixed
- Palatine - mucous
- Lingual:

1. Anterior – mixed
2. Middle – serous
3. Posterior – mucous.



Saliva is an essential fluid for oral cavity maintenance and functionality(Treuting, P.M et al.,2012). Digestive enzymes within saliva initiate the digestion process,and at the same time, saliva acts as a lubricant of solid nutrition,thus helping its passage through the esophagus (Kondo and Nakamoto, 2015). By moisturizing the tongue and other tissues of the oral cavity, saliva has an essential role in speech and taste sensitivity (Matsuo et al., 2000). It also balances the pH of the mouth, thus protecting the soft oral tissues and teeth from an extended exposure to an acidic environment. Saliva contains several signalling molecules, such as EGF, FGF, NGF and TGF-a, that are essential for the regeneration of oral and esophageal mucosa. Finally, the antibacterial and antifungal components of the saliva, such as lysozymes, immunoglobulin and lactoferrin, inhibit the progression of bacterial infection and dental caries.

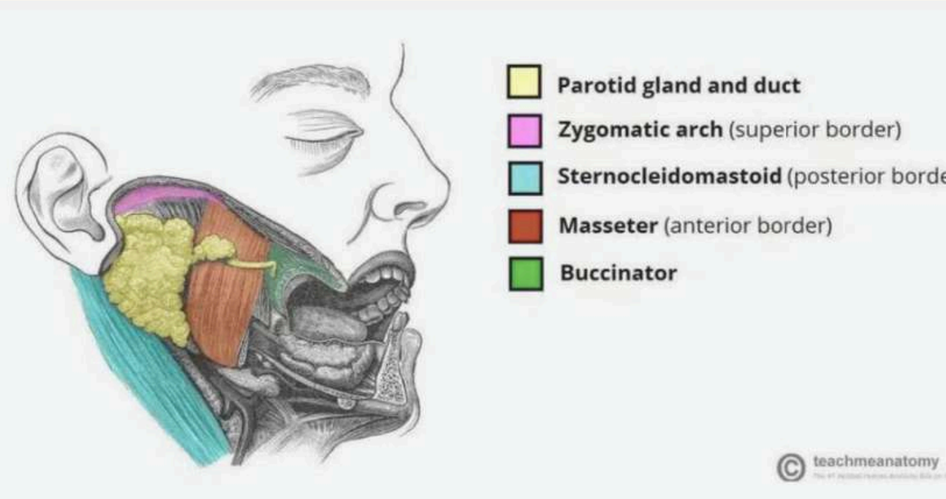
Aim of study

The aim of this study is to able the dentist to discover different methods in imaging of salivary glands for better diagnosis the diseases, and neoplasms that effect major and minor salivary gland in oral and maxillofacial region,

Type of salivary gland

A. parotid gland

The parotid gland (PG) is the largest of the three major salivary glands. resembles an upside-down pyramid. It is located between the sternocleidomastoid muscle and the masseter, extending from the mastoid tip to just below the angle of the mandible . the two parotid glands are present on either side of the mouth and in front of both ears.
The parotid region is bounded as follows:
Superiorly – Zygomatic arch.
Inferiorly – Inferior border of the mandible.
Anteriorly – Masseter muscle.
Posteriorly – External ear and sternocleidomastoid

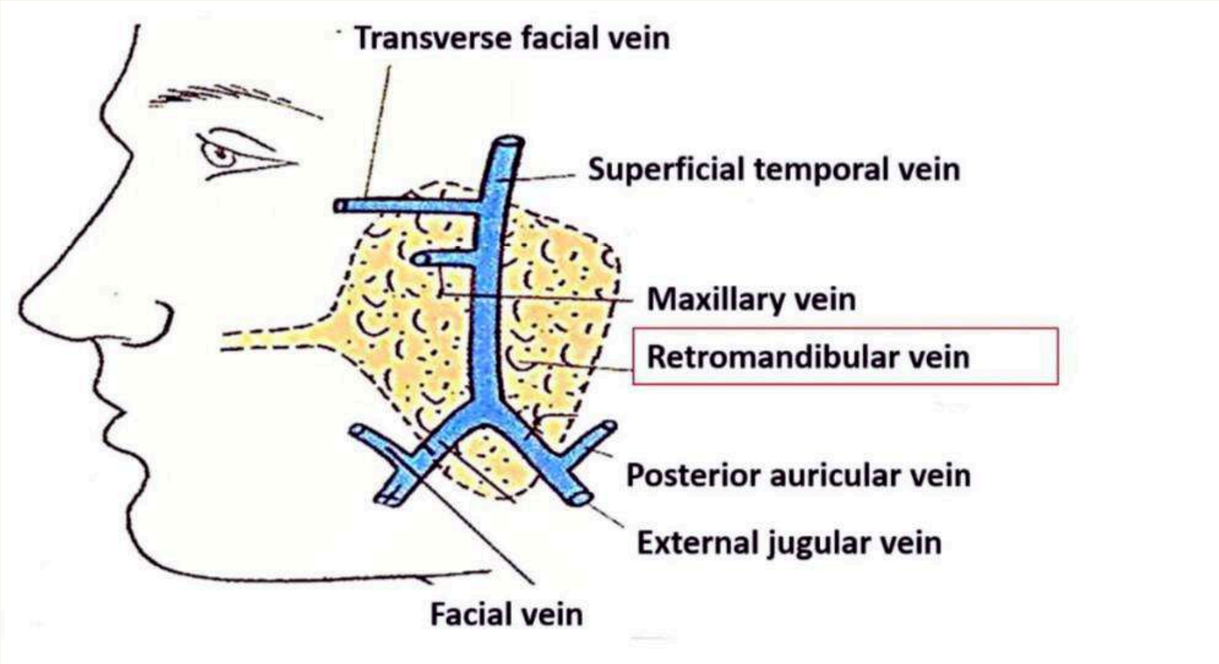


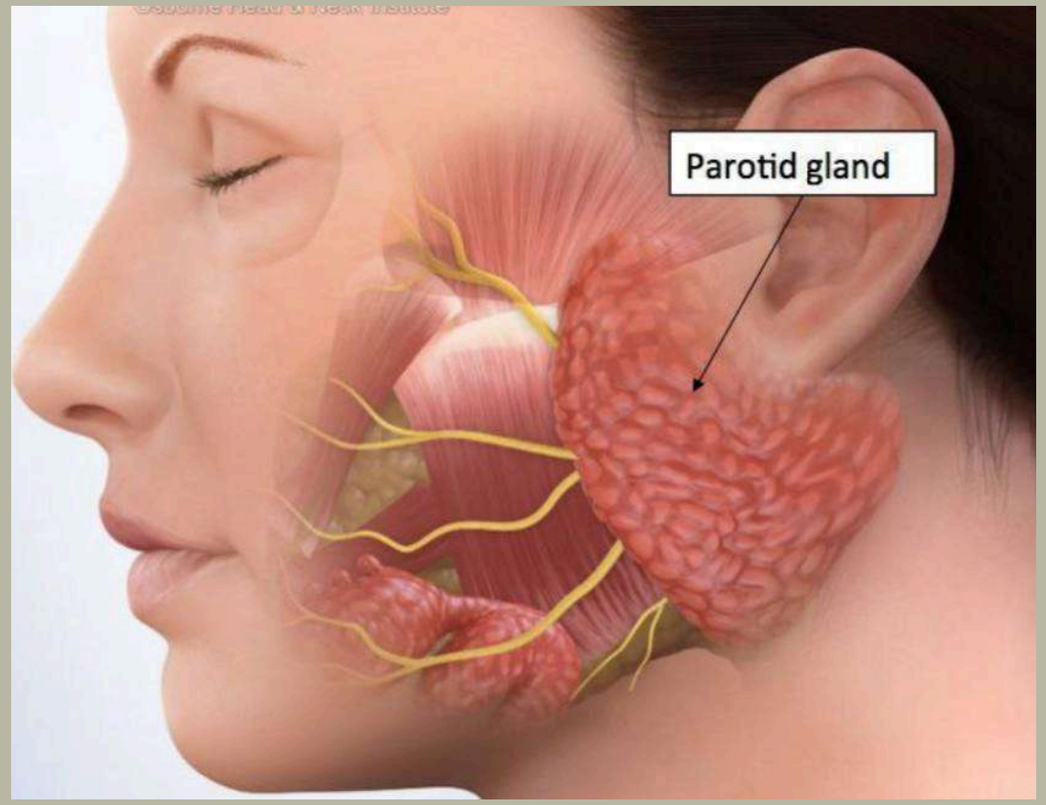
secretes serous saliva through the parotid duct into the mouth, to facilitate mastication and swallowing They also release amylase — a protein that helps jumpstart starch digestion. Saliva is Reduces harmful bacteria in your mouth and Helps protect your teeth from cavities and Keeps your mouth lubricated. The secretions of the parotid gland are transported to the oral cavity by the (Stensen duct) that carries saliva to your mouth, releasing near your upper molar teeth (second upper molar) .

Blood is supplied by the posterior auricular and superficial temporal

arteries. They are both branches of the external carotid artery, which arise within the parotid gland itself.

Venous drainage is achieved via the retromandibular vein. It is formed by unification of the superficial temporal and maxillary veins.



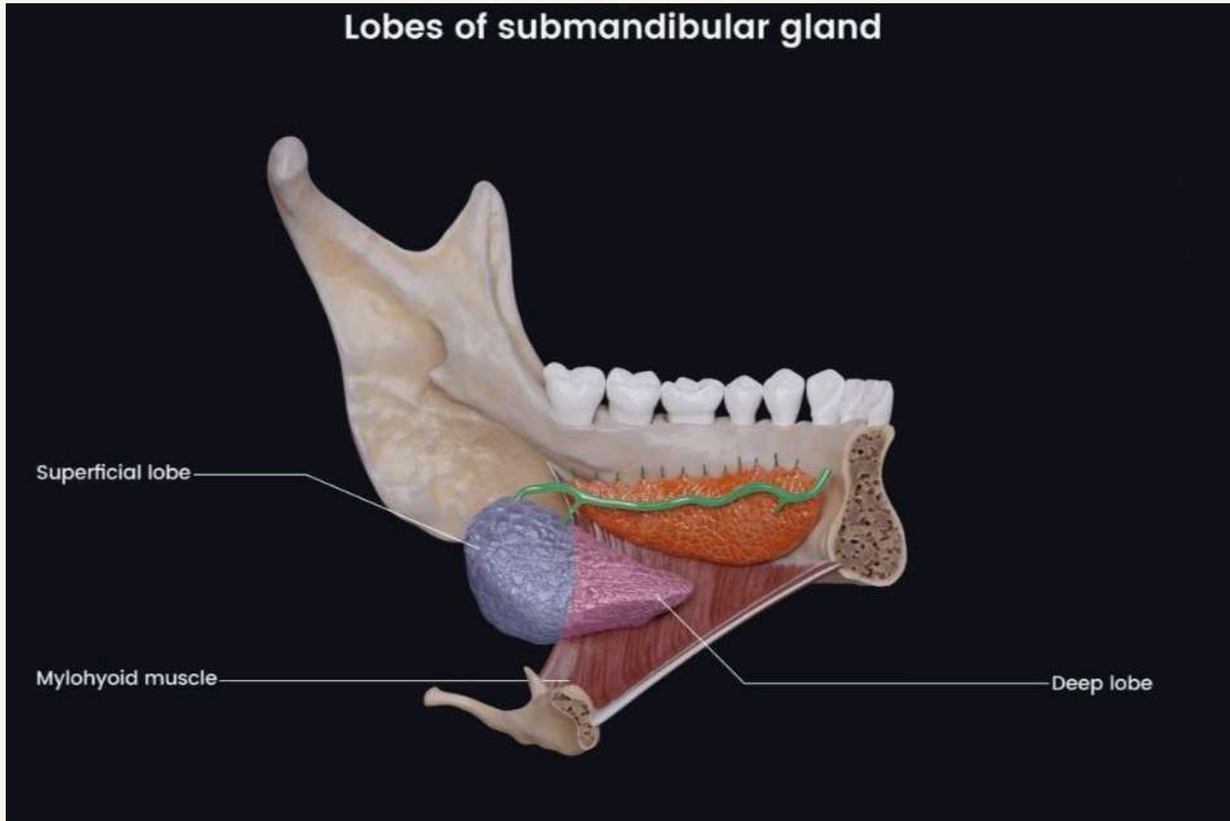


Parotid gland produce 20% of the total salivary content in the oral cavity. Mumps is a viral infection, caused by infection in the parotid gland(Hviid et al., 2008).

B.Submandibular salivary gland:

(historically known as submaxillary glands) is the second largest of the three main salivary glands,is in the posterior portion of the submandibular triangle, submandibular salivary glands consist of two parts:

the superficial lobe and the deep lobe which are separated by the mylohyoid muscle , lobe is larger and lies beneath the deep cervical fascia .



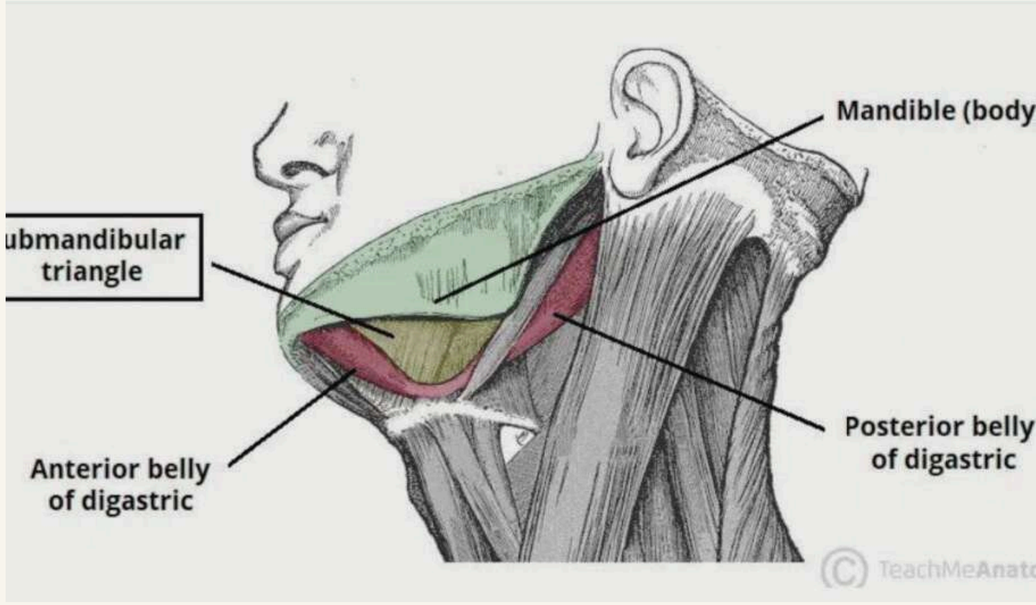
This gland can usually be felt via palpation of the neck, as it is in the superficial cervical region and feels like a rounded ball. It is located about two fingers above the Adam's apple and about two inches apart under (laryngeal prominence) the chin.

The submandibular gland is located within the anterior part of the submandibular triangle.

The boundaries of this triangle are:

Superiorly: Inferior body of the mandible.

Anteriorly: Anterior belly of the digastric muscle.



The submandibular gland’s main excretory duct is the (Wharton duct.) is the excretory duct of the gland. It drains saliva from the glands at the base of the tongue. that transports saliva to the floor of your mouth (under your tongue) ,The secretion produced is a mixture of both serous fluid and mucus,and enters the oral cavity via the submandibular duct or Wharton duct The mucinous acini’s primary protein is mucin, which functions to lubricate and competitively inhibit bacterial attachment to the salivary duct epithelium, allowing for antimicrobial protection of the submandibular gland. The serous acini’s primary protein is amylase, which functions to help metabolize starches in the oral cavity .

The submandibular glands receive their primary blood supply from the submental and sublingual arteries, which are branches of the facial artery and lingual artery, respectively, both of which are branches of the external carotid artery. submandibular gland produces the most saliva (approximately 70%) in the unstimulated state

C.Sublingual salivary gland:

smallest of the three major salivary glands [1] located inferior to the tongue, anterior to the submandibular glands (Bialek EJ et al., 2006). of major and minor salivary glands, which

occupies much of the submucosa of the floor of the mouth extending posteriorly to the second molar region.[1]The sublingual gland acquires an oval shape when sectioned

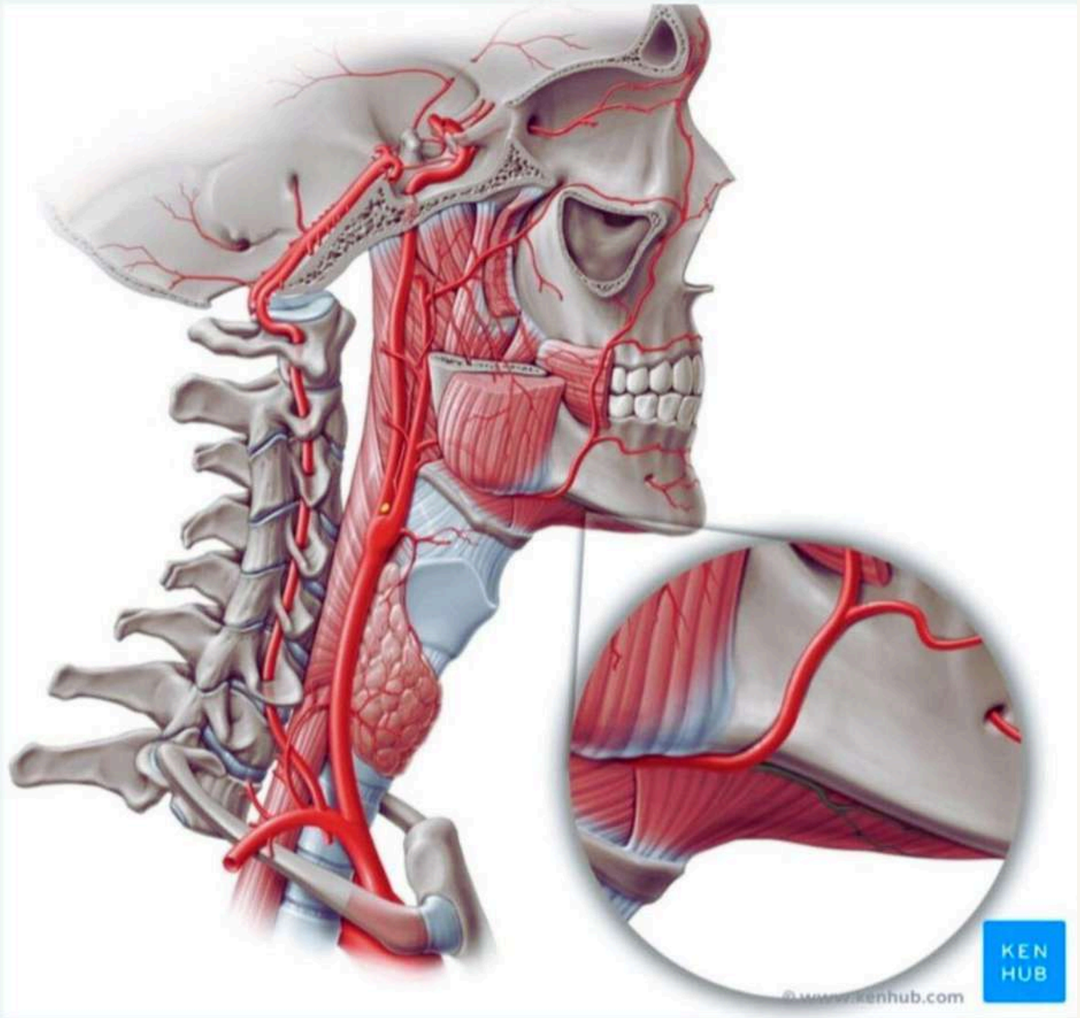
transversely, however, the gland shape is longitudinal and lentiform when sectioned parallel to the body of the mandible [2]. The gland is composed of a major sublingual gland and around eight to thirty minor sublingual glands.

There are two separate arterial supplies

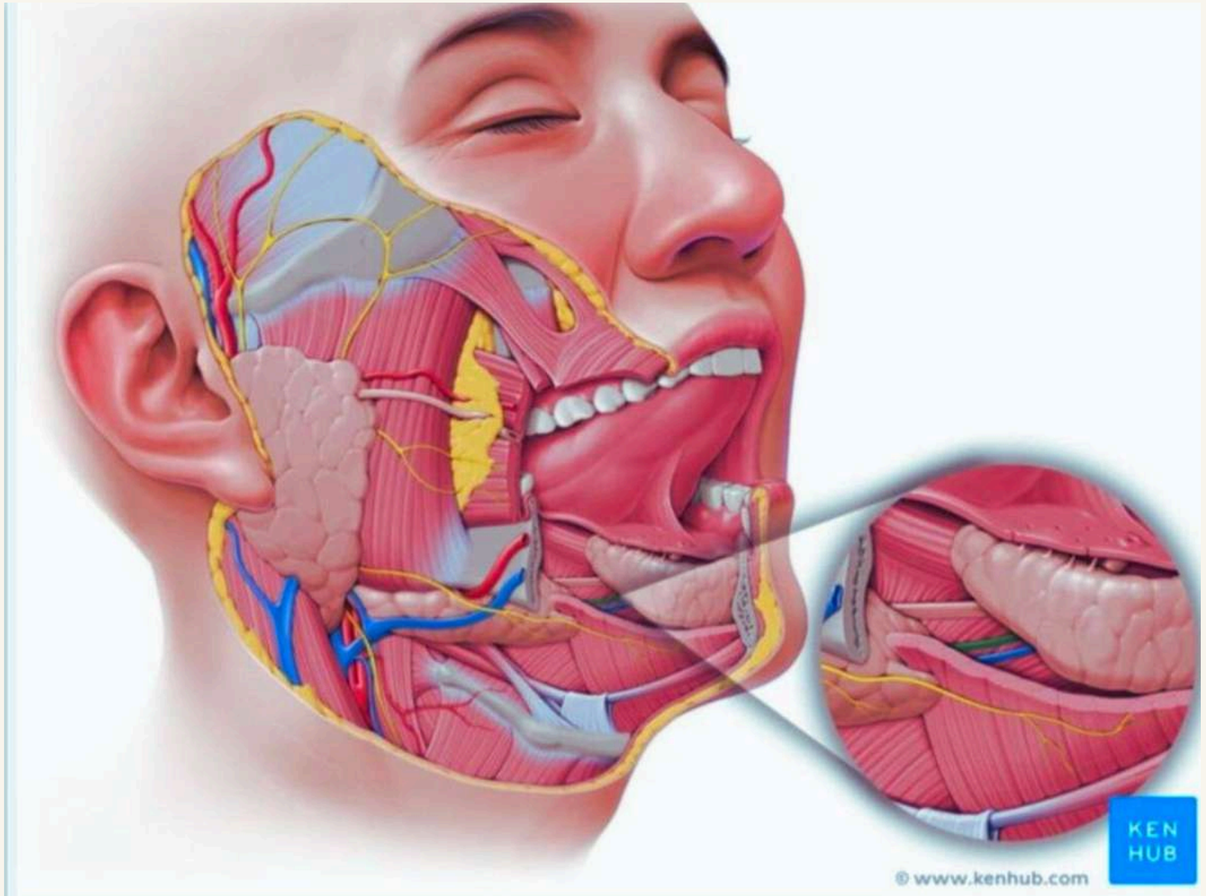
1.the lingual artery which branches into the sublingual artery.

2.facial artery which gives rise to the submental artery.

These arteries are both branches of the external carotid artery.



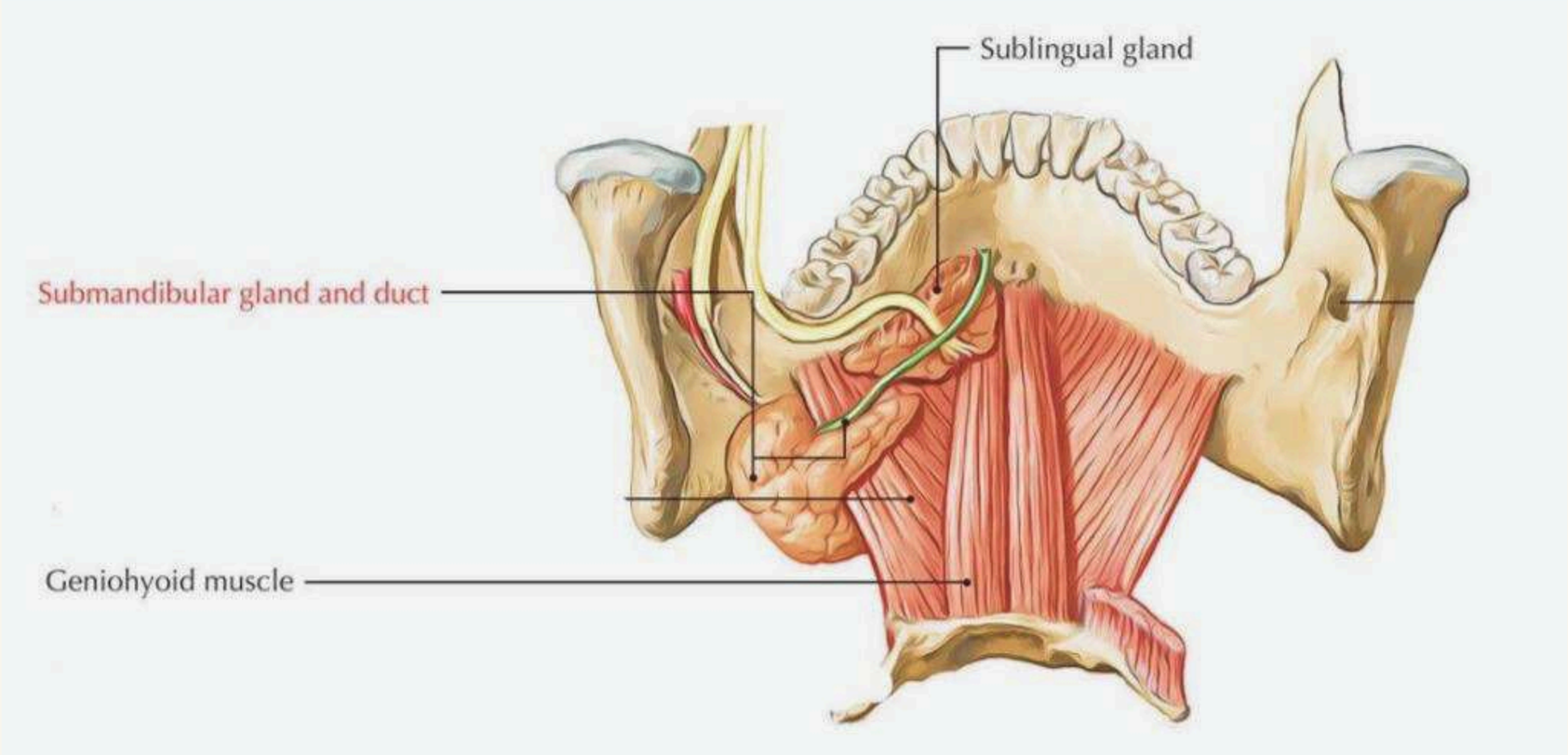
Submental artery



Sublingual artery

They are bordered

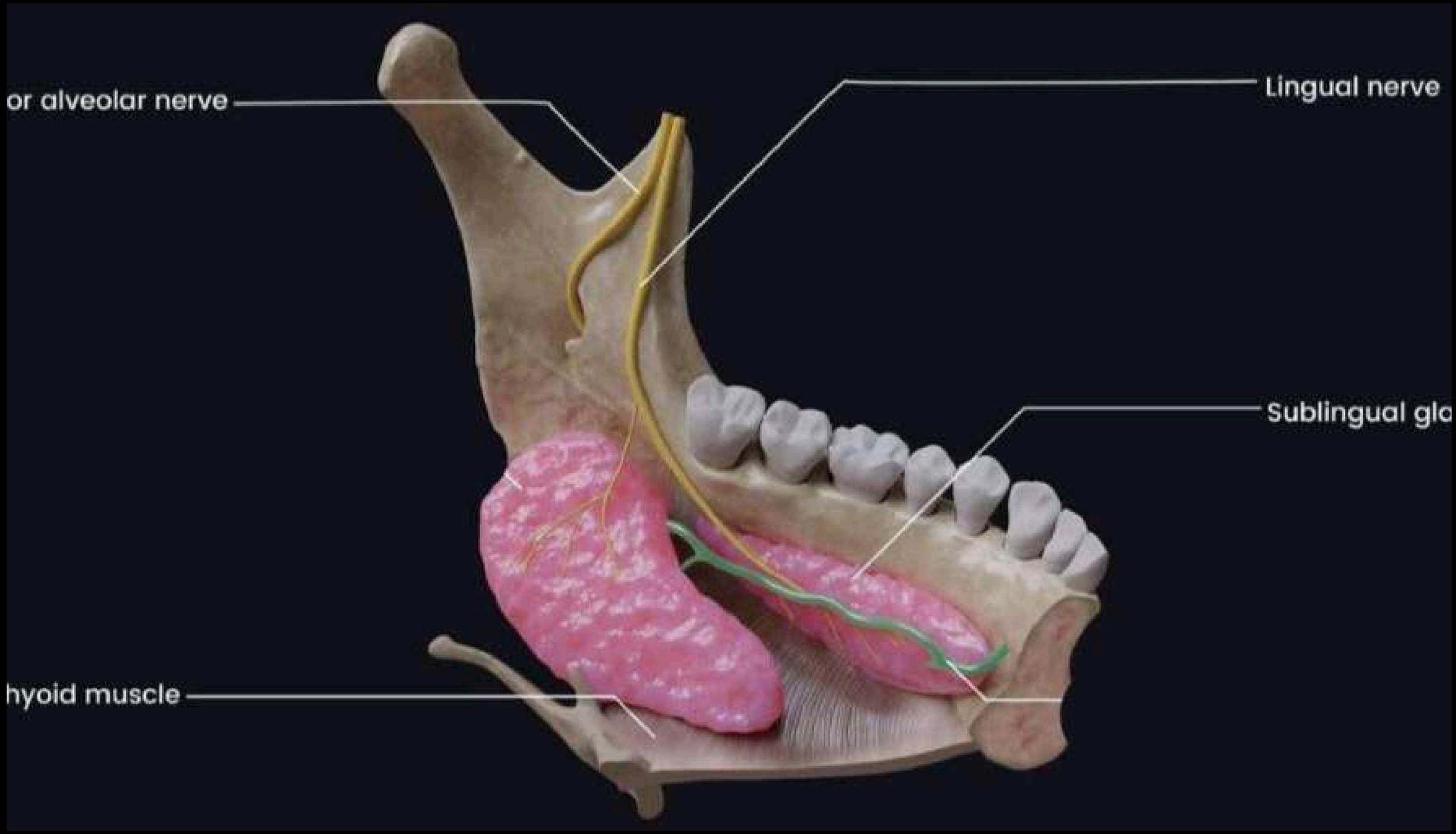
1. anteroinferiorly (laterally)/ mandible
2. posteroinferiorly(medially) /genioglossus muscle
3. superiorly/ tongue



The sublingual glands produce very little saliva-only between 3% and 5% of the total volume and make secretions composed predominantly of mucus, a slippery liquid that lubricates and protects organs. The secretions produced by the sublingual glands aid in the earliest stages of digestion and keep the inside of your mouth moist.

Secretions produced by the sublingual glands drain into your mouth through ducts called minor sublingual ducts, or ducts of Rivinus. Each duct has between eight and 20 ducts. Some people with abnormal duct structure have a major sublingual duct, also called the duct of Bartholin.

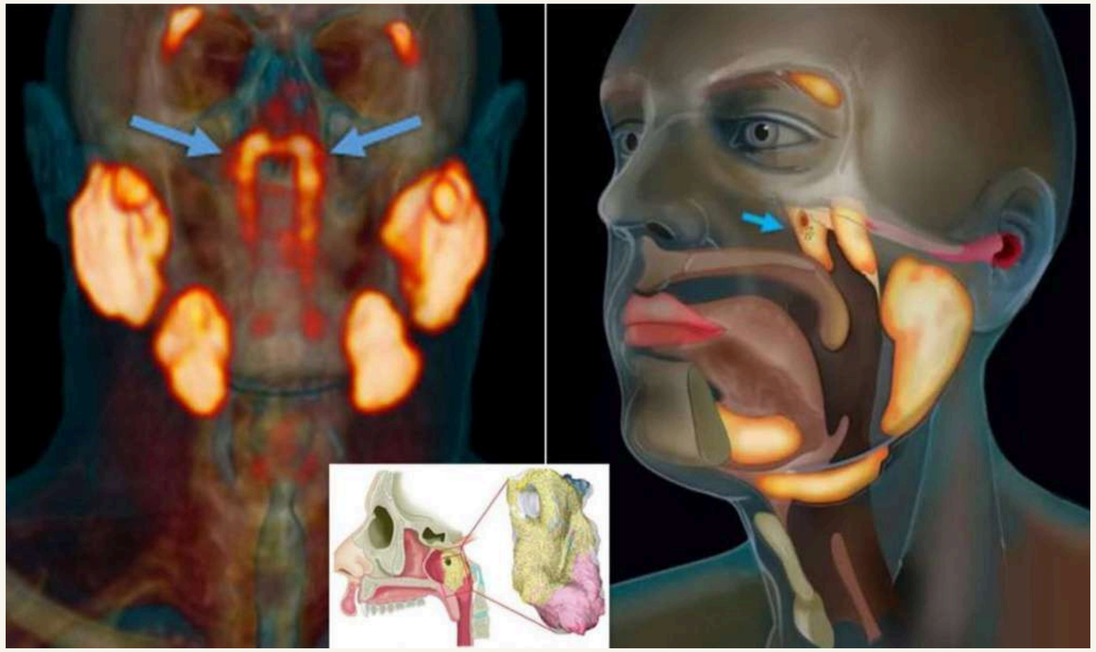
Ranulas are the most common pathologic lesion associated with the sublingual glands.

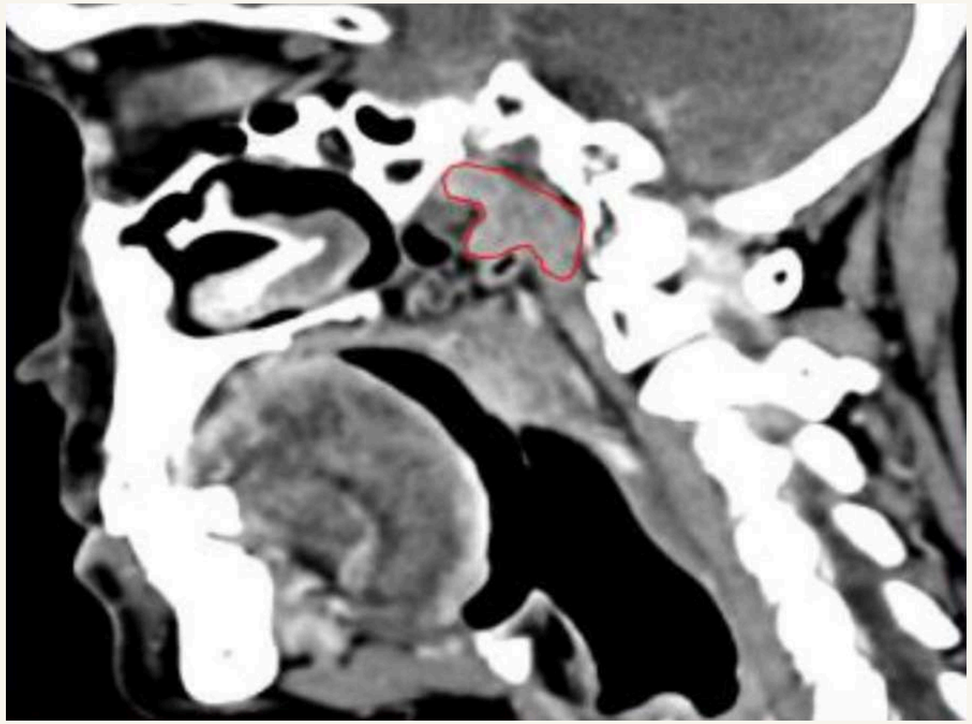

or alveolar nerve
Lingual nerve
Sublingual gla
hyoid muscle

D- **Tubarial salivary gland**

The tubarial glands are suggested as fourth pair of salivary glands situated posteriorly in the nasopharynx and nasal cavity, predominantly with mucous glands, and its ducts opening into the dorsolateral pharyngeal wall. The glands were unknown until September 2020, when they were discovered by a group of Dutch scientists using with prostate-specific membrane antigen PET-CT.

This discovery may explain mouth dryness after radiotherapy despite the avoidance of the three majorglands. However, these findings from just one study need to be confirmed (Valstar et al.,
2020)(Wu, Katherine J, 2020). On the other hand, an interdisciplinary group of scientists disagree with this new discovery. They believe that an accumulation of minor salivary glands has been described (Guntinas-Lichius et al., 2020).



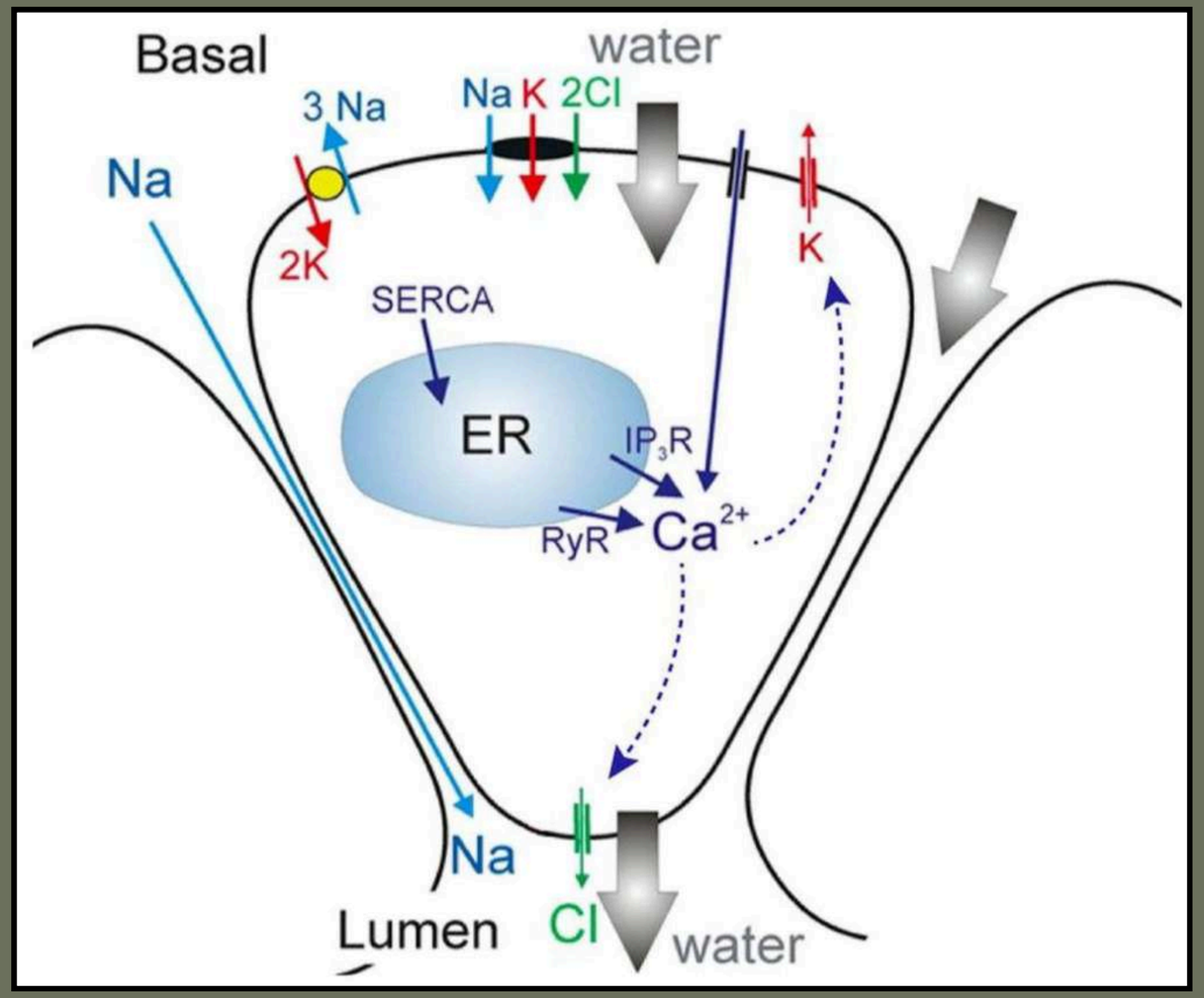


Chemistry and mechanism of secretion

The mechanism of salivary gland secretion involves primarily cholinergic signaling by the parasympathetic nerves and signaling by neuropeptides like substance P, but also adrenergic signaling by sympathetic nerves.

Parasympathetic stimulation will activate acetylcholine receptors to activate protein kinase C (PKC), releasing diacylglycerol (DAG) and inositol triphosphate (IP3) which stimulate increased intracellular calcium levels. The rise in calcium mediates the increased volume of saliva and amylase output. Substance P will activate the neurokinin-1 (NK-1) receptor to similarly stimulate PKC to increase the formation of IP3 and DAG, which subsequently increase amylase output and volume flow.

Sympathetic stimulation will increase alpha receptor stimulation by norepinephrine which causes smooth muscle contraction and increases volume flow and amylase output. Norepinephrine will also act on beta receptors and activate the cyclic adenosine monophosphate cascade, increasing protein kinase A (PKA) activity, amylase output, and transient saliva volume flow.



There are two main stages to the secretion of saliva. First, once stimulated, acinar cells secrete primary saliva which is isotonic and contains amylase, mucus, and extracellular fluid. This isotonic form of saliva is made by secreting sodium chloride. In the second stage, the primary saliva gets modified as it passes down the ductal tree. The sodium gets actively reabsorbed, potassium is actively secreted, chloride is passively absorbed, and bicarbonate secreted. Of note, the ductal epithelium has poor water permeability. The final saliva product will be hypotonic.

function of saliva

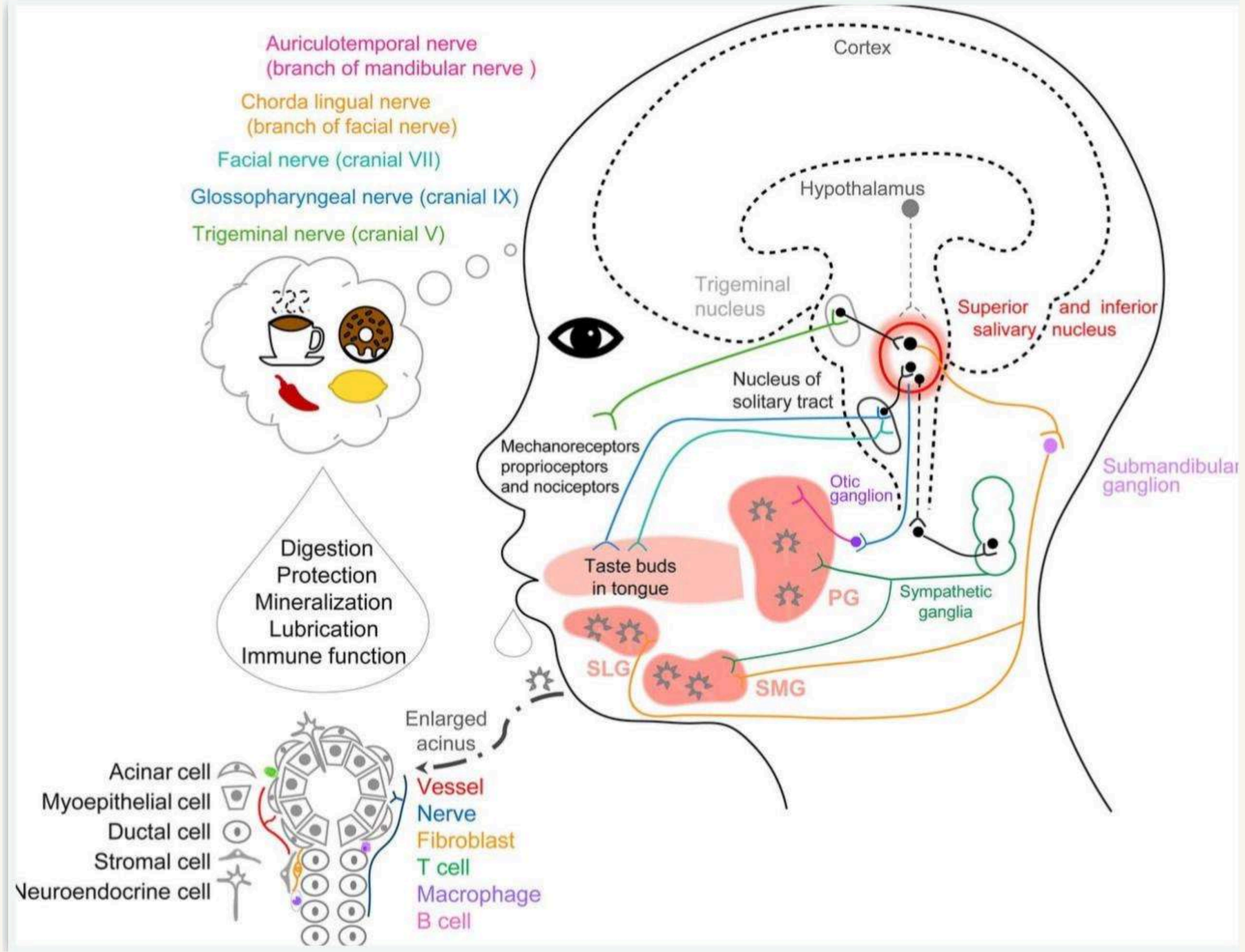
Nature's demands on salivary glands are extensive and diverse and range from the reptilian need for a venomous drop to incapacitate its prey to the 100 quarts that ruminants require to digest a day's grazing. Other species depend on saliva not for survival, but for improving the quality of life, using the fluid for functions varying from grooming and cleansing to nest-building.

Humans can manage without saliva; its loss is not life-threatening in any immediate sense, but it results in a variety of difficulties and miseries. Oral digestion per se is only of marginal importance in humans, but saliva is important in preparing food for mastication, for swallowing, and far normal taste perception. Without saliva, mealtimes are difficult, uncomfortable, and embarrassing. The complex mix of salivary constituents provides an effective set of systems for lubricating and protecting the soft and hard tissues.

Protection of soft tissues is afforded against desiccation, penetration, ulceration, and potential carcinogens by mucin and anti-proteases. Saliva can encourage soft tissue repair by reducing clotting time and accelerating wound contraction.

function of saliva

A major protective function results from the salivary role in maintenance of the ecological balance in the oral cavity via; (1) debridement/ lavage; (2) aggregation and reduced adherence by both immunological and nan-immunological means; and (3) direct antibacterial activity. Saliva also possesses antifungal and anti-viral systems. Saliva is effective in maintaining pH in the oral cavity, contributes to the regulation of plaque pH, and helps neutralize reflux acids in the esophagus. Salivary maintenance of tooth integrity is dependent on: (1) mechanical cleansing and carbohydrate clearance; (2) post-eruptive maturation of enamel; (3) regulation of the ionic environment to provide a remineralizing potential without spontaneous precipitation; and (4) pellicle deposition and limitation of acid diffusion. Saliva also plays a role in water balance, can serve in a limited way in excretion, and has possible hormonal function in the gastro-intestinal tract.


Auriculotemporal nerve
(branch of mandibular nerve)
Chorda lingual nerve
(branch of facial nerve)
Facial nerve (cranial VII)
Glossopharyngeal nerve (cranial IX)
Trigeminal nerve (cranial V)
Cortex
Hypothalamus
Trigeminal nucleus
Superior and inferior salivary nucleus
Nucleus of solitary tract
Mechanoreceptors proprioceptors and nociceptors
Otic ganglion
Submandibular ganglion
Taste buds in tongue
PG
Sympathetic ganglia
SLG
SMG
Digestion
Protection
Mineralization
Lubrication
Immune function
Enlarged acinus
Acinar cell
Myoepithelial cell
Ductal cell
Stromal cell
Neuroendocrine cell
Vessel
Nerve
Fibroblast
T cell
Macrophage
B cell

Composition of saliva

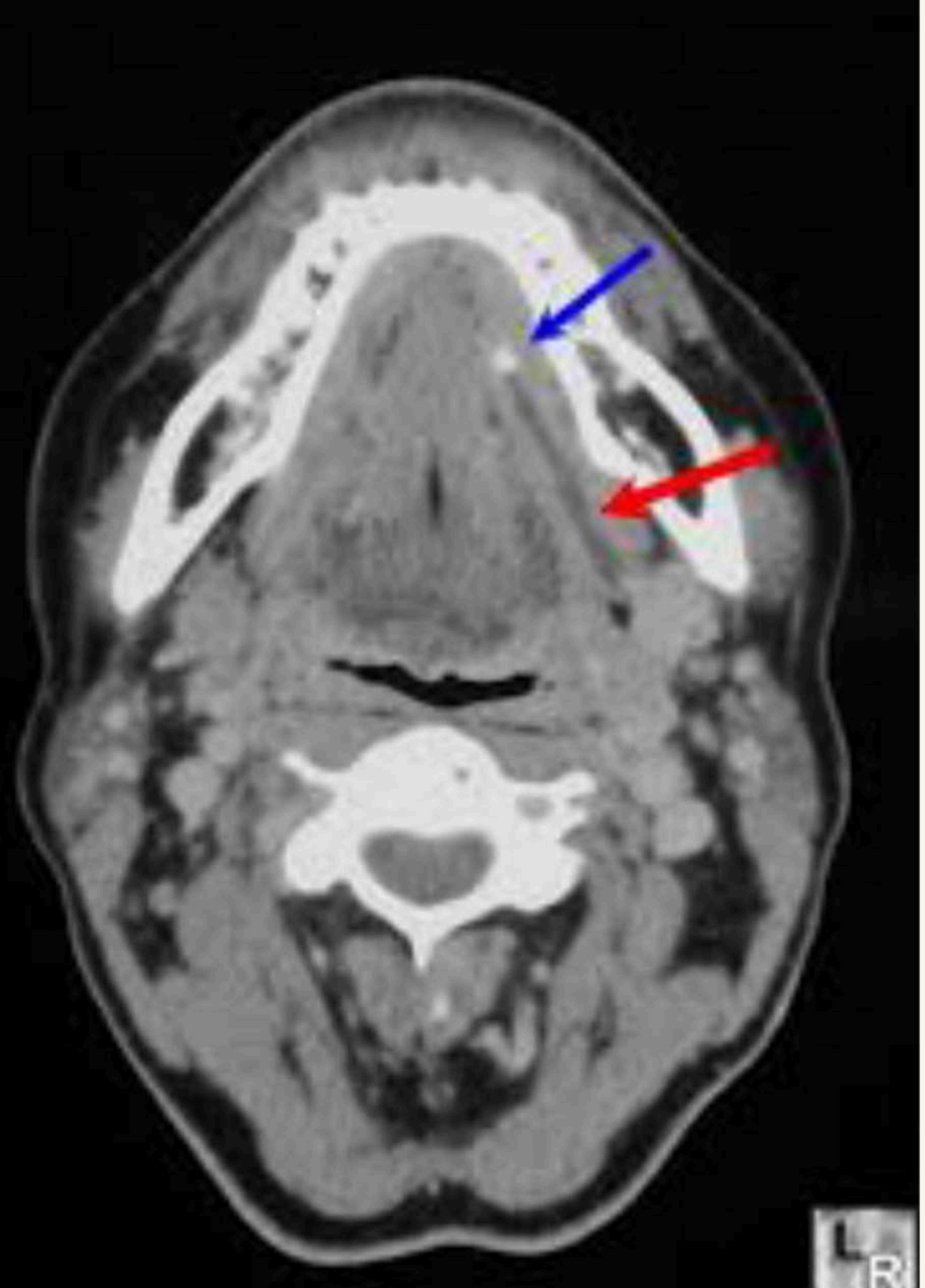
Saliva is composed of a variety of electrolytes, including sodium, potassium, calcium, magnesium, bicarbonate, and phosphates. Also found in saliva are immunoglobulins, proteins, enzymes, mucins, and nitrogenous products, such as urea and ammonia. These components interact in related function in the following general areas:

(1) bicarbonates, phosphates, and urea act to modulate pH and the buffering capacity of saliva;
(2) macromolecule proteins and mucins serve to cleanse, aggregate, and/or attach oral microorganisms and contribute to dental plaque metabolism;
(3) calcium, phosphate, and proteins work together as an antisolubility factor and modulate demineralization and remineralization; and
(4) immunoglobulins, proteins, and enzymes provide antibacterial action.

salivary gland disease:

1.Sialolithiasis

Sialolithiasis is a benign condition involving the formation of stones within the ducts of the major salivary glands: parotid, submandibular, and sublingual glands. It is the most frequent cause of salivary gland swelling, with a reported incidence of 1 in 10000 to 1 in 30000.In some cases, sialoliths can obstruct the salivary ducts, leading to inflammation, superimposed bacterial infection termed sialadenitis, or in rare cases, abscess formation. There are various presenting symptoms, with the most common being cyclical postprandial swelling of the affected gland and decreased salivary flow.



In the case of larger salivary stones involving the distal submandibular duct (Wharton's duct), diagnosis is often possible based on physical examination. Cases involving smaller stones within the distal submandibular duct or parotid duct (Stenson's duct) were historically diagnosed utilizing conventional radiography, sialography, and digital subtraction sialography.

Modern diagnostic techniques involve point-of-care ultrasound, computed tomography (CT), magnetic resonance imaging (MRI), and direct visualization with sialoendoscopy. A variety of treatment options exist for sialolithiasis, including sialogogues, direct massage of distal stones out of the duct, and other procedures including interventional sialography, lithotripsy, sialoendoscopy, and surgery.

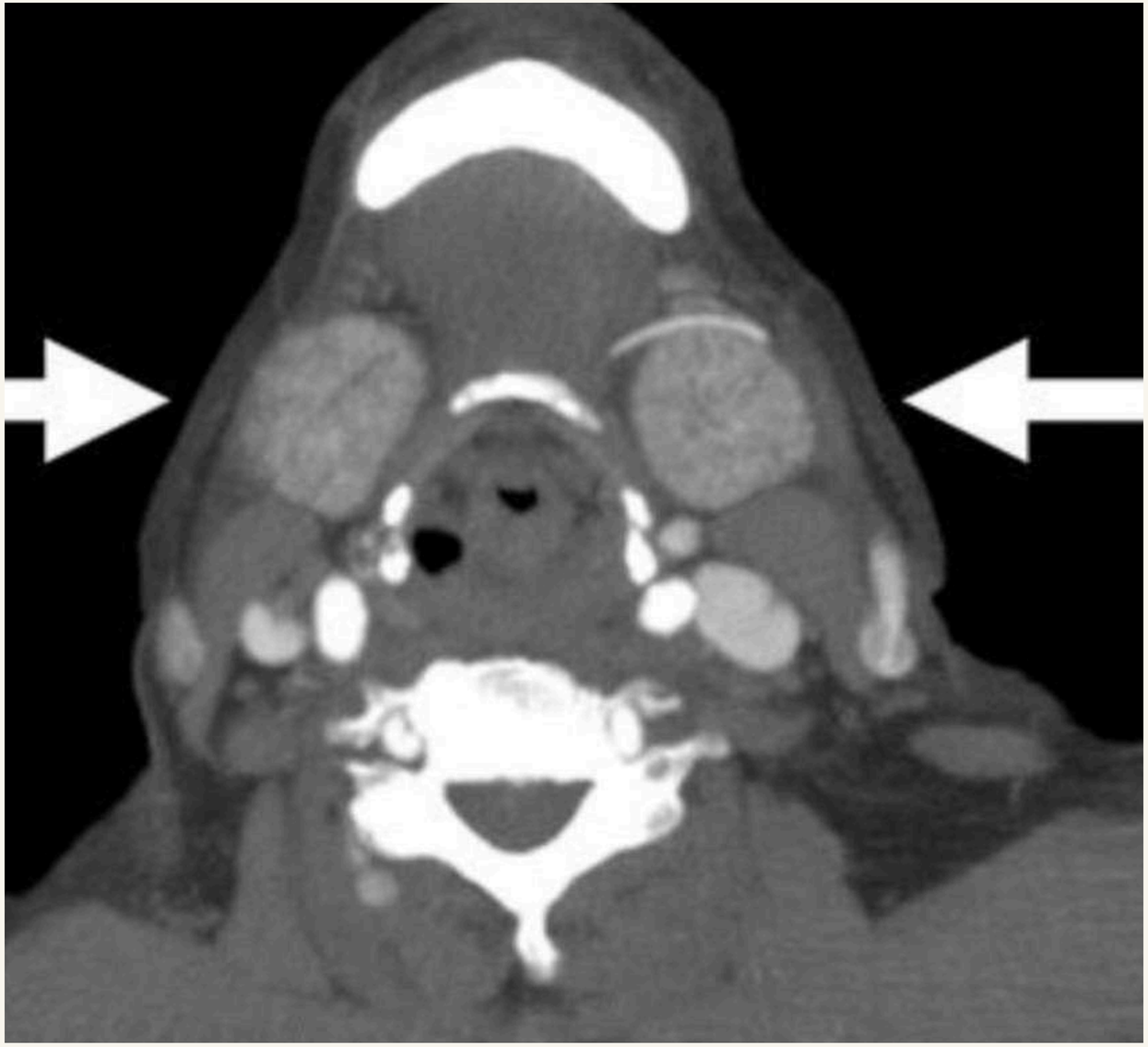
2. Infections

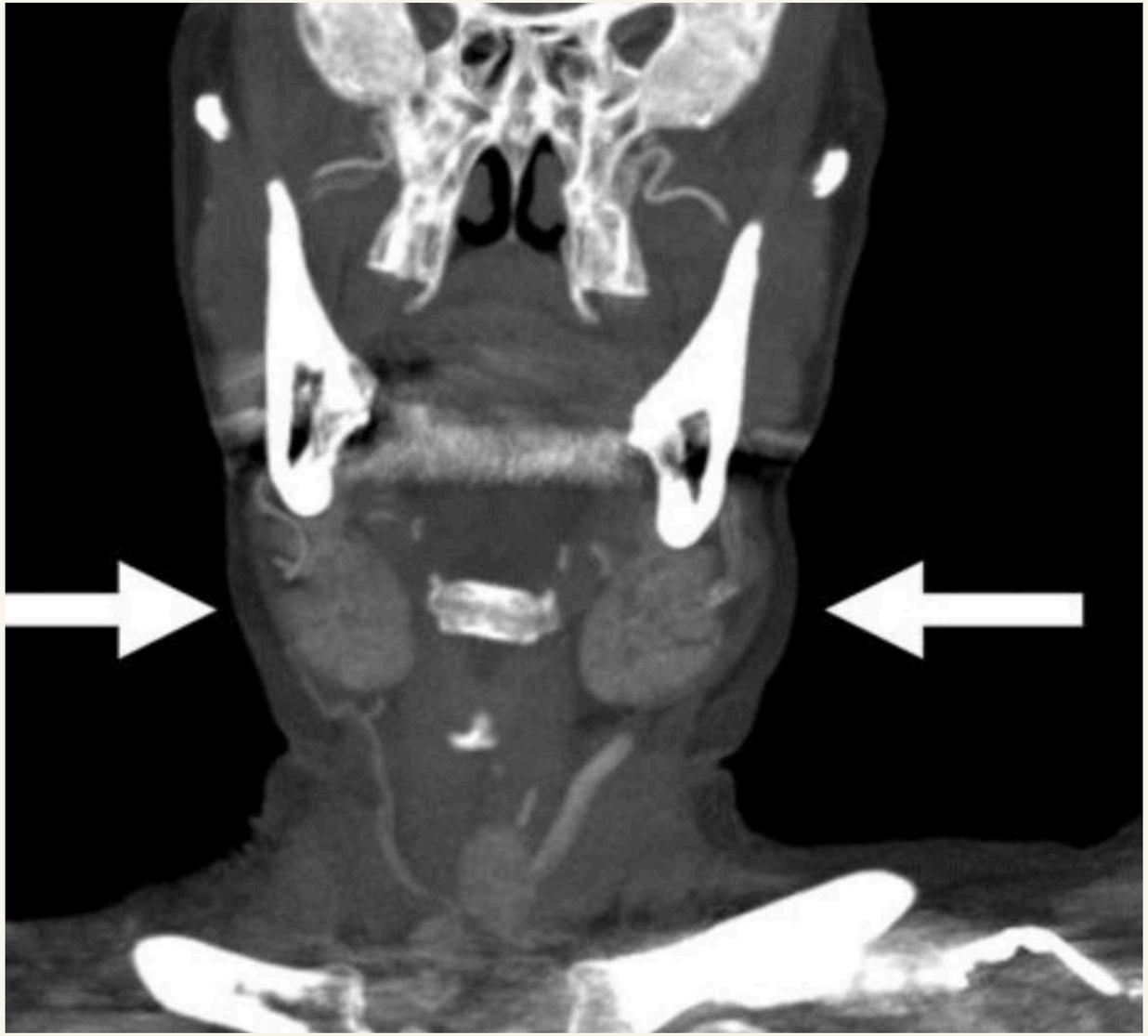
A. Viral infection (Mumps)

Mumps is a contagious viral illness and at one time was a very common childhood disease. With the implementation of widespread vaccination, the incidence of mumps in the population has decreased substantially. Mumps infection typically presents with a prodrome of headache, fever, fatigue, anorexia, malaise followed by the classic hallmark of the disease, parotitis. The disease is more often self-limited with individuals experiencing a full recovery.

Mumps is caused by the Rubulavirus and a member of the paramyxoviridae family. Mumps affects people globally and is the only known cause of epidemic parotitis. The majority of mumps cases are seen in late winter and early spring.

Risk factors for mumps include immunodeficiency, international travel and lack of vaccination.





B.Bacterial infection (sialadenitis)

Chronic sialadenitis is characterized by recurrent or persistent of the salivary gland. Chronic sialadenitis is usually due to obstruction, e.g., calculi, stricture, and usually presents with swelling without erythema. Sialdenosis is nonneoplastic,non-inflammatory swelling of the salivary gland in association with acinar hypertrophy and ductal atrophy. Sialdenosis presents as non-tender swelling that is often bilateral and symmetric. Sialadenosis is often associated with systemic metabolic conditions.

Treatment / Management

1. **Acute sialadenitis:** Most cases receive treatment with conservative medical management; this includes hydration, warm compresses, and massage, pain relief with analgesics (e.g., NSAIDs), sialogogues. Empiric antibiotic therapy starts with amoxicillin/clavulanate or clindamycin. Antibiotics selection should be according to culture and sensitivity reports. Intravenous antibiotics may be necessary for severe cases. If soft tissue swelling is significant, and there is no contraindication, corticosteroid therapy is an option. Rarely, acute suppurative sialadenitis can lead to abscess formation; surgical incision and drainage are indicated in these cases.
2. **Chronic sialadenitis:** Medical management is with hydration, oral hygiene, pain relief, sialogogues. In cases of infection, broad-spectrum antibiotics are added. In the case of sialolithiasis, salivary gland stone removal should take place, using interventional sialendoscopy or direct surgical removal. EWSL under ultrasonic guidance is used for intraglandular duct stone removal. Recurrent sialadenitis (>3 episodes/year) or in chronic sclerosing sialadenitis: excision of the salivary gland is the recommendation.
3. **Sialadenosis**: Sialadenosis requires expectant management. Treatment of underlying cause is the approach taken.

3.eysts of salivary glands:

A. Mucocele

Mucocele is a common salivary gland disorder that can appear in the lacrimal sac, paranasal sinuses, oral cavity, appendix, or gall bladder. These lesions occur due to mucous accumulation resulting from the alteration of minor salivary glands. Lower lip is the most common site of occurrence of these lesions in the oral cavity and most probable cause is trauma or habit of lip biting mucocele in children treated by conventional surgical excision of the lesion.

Mucoceles present as bluish, soft, and transparent cystic swelling that frequently resolve spontaneously.

Blue color is due to vascular congestion, cyanosis of the tissue above, and accumulation of fluid below.

However, coloration may vary depending on the size of the lesion, proximity to the surface, and elasticity of overlying tissue

B. Ranulas

Ranulas are mucoceles that are of major salivary gland origin and occur on the floor of the mouth. Like mucoceles, these lesions also have two types: oral ranulas and cervical/plunging ranulas. While the oral ranulas form because of leakage and accumulation of secretions of major salivary gland above the mylohyoid muscles, cervical/plunging ranulas result from the collection of mucus along the fascial planes of the neck the oral ranulas form because of leakage and accumulation of secretions of major salivary gland above the mylohyoid muscles, cervical/plunging ranulas result from the collection of mucus along the fascial planes of the neck..

Treatment / Management

Mucoceles and ranulas tend to resolve spontaneously. But if they are symptomatic, persistent, and are not self-resolving, multiple treatment approaches can be considered, which are discussed below.

• Mucoceles

1. Surgical Excision: Surgical excision of the
mucocele along with the associated minor salivary gland, is preferred when the lesion is persistent, recurrent, or symptomatic. After adequate removal, the chances of recurrence are reasonably low.

2. Aspiration: It is not considered as an appropriate therapy for mucoceles as the recurrence rate is quite higher. Instead, it is preferred to eliminate other entities before surgical excision.

3. Marsupialization: It is performed when the lesion is more extensive as it prevents the significant loss of the tissue and also decreases the risk of complications occurring as a result of surgical excision. However, if it fails, then surgical removal of the lesion is performed. Micromarsupialization of lesions smaller than 1 cm in diameter has been reported in pediatric patients with variable success in which a suture is taken through the dome of the lesion, allowing re-epithelialization of the injured duct and improving the secretory flow of the minor salivary gland.

4. Laser Ablation, Cryosurgery, and Electrocautery: They are mostly performed for the superficial mucoceles.

Treatment / Management

• Ranulas

1. Surgical Excision: Both oral and cervical ranulas can be treated effectively with this approach involving the removal of the lesion along with the associated major salivary gland with insignificant recurrence rates.

2. Marsupialization: Some providers prefer it before embarking on surgical removal. The whole pseudocyst is packed with gauze for 7-10 days. This allows re-epithelialization of the cavity and also seals off the leakage site. Besides, it also provokes a foreign body reaction causing fibrosis and atrophy of the offending acini. If marsupialization fails to eliminate the disease, then surgical excision is the next treatment of choice.

3. Laser Ablation, Cryosurgery, and Electrocautery: These have also been employed for the treatment of smaller ranulas either alone or before the marsupialization.

4. Intralesional Injection of a Sclerosant Agent:

Although considered experimental, intracystic injection of the streptococcal preparation, OK-432, has been reported to treat the disease with variable success rates.

4. tumors

Tumours originating in salivary gland tissue are often benign. In minor salivary glands, the most commonclinical complication is the formation of mucus retention cysts, a non-malignant evolution of the altered tissue.

Type	Origin	Most common location	Metastasis
Mucoepidermoid Carcinoma	Excretory stem cells	PG	Yes, regional lymphnodes
Adenoid Cystic Carcinoma	Intercalated stem cells	minor SG	Yes, lungs
Acinic Cell Carcinoma	Intercalated stem cells	PG	
Polymorphous Adenocarcinoma	Intercalated ductal cells	Minor SG	Rarely Perineural lymphnodes
Squamous Cell Carcinoma	Excretory stem cells	PG, SMG	Neck region
Non-Hodgkin lymphoma	Inltrating immune cells	PG	
Pleomorphic adenoma	Intercalated stem cells	PG	no

5. xerostomia

Dry mouth is a condition in which the salivary glands in the mouth do not produce enough saliva to keep the mouth moist. Dry mouth often occurs due to aging, side effects of certain medications, or radiation therapy for cancer. In rare cases, dry mouth may be caused by a disease in the salivary glands.

Symptoms

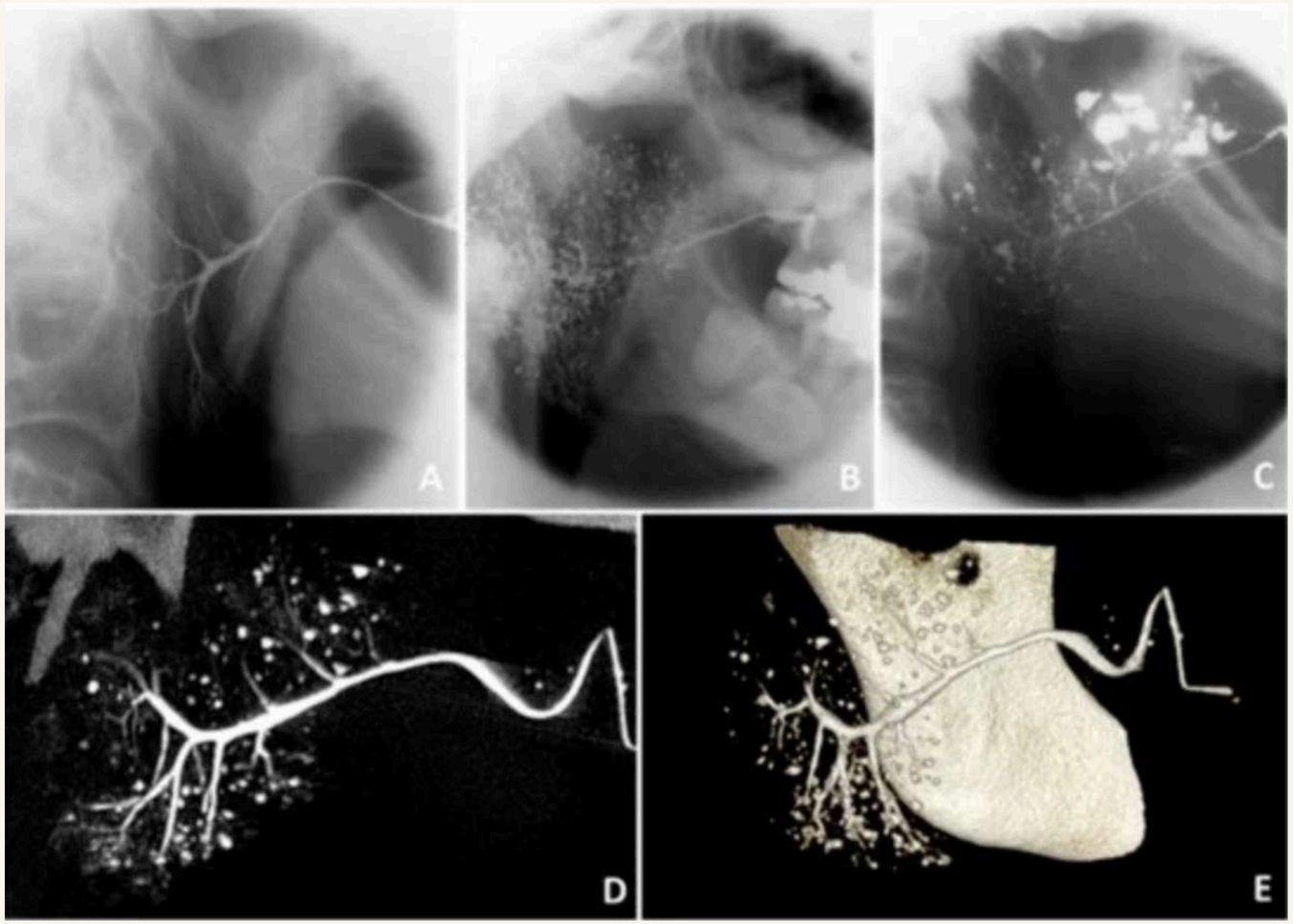
1. Dry mouth or a feeling of stickiness.
2. The consistency of saliva is heavy and it appears in the form of strands.
3. Bad breath.
4. Difficulty chewing, speaking and swallowing.
5. Dry or sore throat and hoarseness.
6. Dry or cracked tongue.
7. Change in sense of taste.
8. Problems when using dentures.
9. Lipstick impression on teeth.

the reasons

1. Medications/Medications most likely to cause problems include medications for depression, high blood pressure, and anxiety, as well as some antihistamines, decongestants, muscle relaxants, and pain relievers.
2. Getting older
3. Cancer treatment. Medicines used to treat cancer (chemotherapy) can change the nature and amount of saliva.
4. Nerve damage. An injury or surgery that causes nerve damage in the head and neck area can lead to dry mouth.
5. Cancer treatment. Medicines used to treat cancer (chemotherapy) can change the nature and amount of saliva.
6. Nerve damage. An injury or surgery that causes nerve damage in the head and neck area can lead to dry mouth.
7. Other health conditions. Dry mouth can be caused by certain health conditions, such as diabetes, stroke, oral yeast infection, or Alzheimer's disease. Or dry mouth may be caused by autoimmune diseases, such as Sjögren's syndrome or HIV/AIDS.
8. Snoring and mouth breathing. Snoring and keeping the mouth open while breathing can lead to dry mouth.
9. Tobacco use and alcohol consumption. Drinking alcohol, smoking, or chewing tobacco can cause further symptoms of dry mouth

6.Primary Sjögren's Syndrome

Primary Sjögren's syndrome (pSS) is a systemic autoimmune disease affecting salivary and lacrimal glands. Often accompanying other omune system disorders (such as lupus and rheumatoid arthritis), its dain effect is the loss of mucous membrane and moisture-secreting gland cells, resulting in xerostomia and xerophthalmia. Although the pathogenesis of the disease remains largely unknown, the role of the B- lymphocytes appears to be essential in the initiation of the disease, Members of the TNF superfamily (such as BAFF/APRIL) are produced not only by patrolling immune cells but also by the epithelial cells of the salivary glands. Through these pathways, B-cells are activated and start to proliferate in an uncontrolled manner. Their pivotal role includes intration of the salivary glands to produce an ectopic germinal centre and local secretion of autoantibodies. The centre can grow independently from the surrounding tissue and can evolve in more complex diseases such as non-Hodgkin lymphoma.



Findings on sialography. Sialographies of the parotid gland showing (A) no abnormalities in a healthy subject, (B) punctate/globular sialectasis in a pSS patient, and (C) globular/cavitary sialectasis in a pSS patient [29]. (D) Two-dimensional sialo-CBCT image and (E) three-dimensional sialo-CBCT image of the parotid gland of a pss patient, showing normal width of the primary duct, moderate scarcity of ductal branches, and numerous diverse sialectasis.

treatment

1. Change the medication that causes dry mouth.
2. Recommending the use of products to moisturize the mouth. Oral moisturizing products include prescription medications, over-the-counter mouthwashes, artificial saliva, or lubricants. Mouthwashes, especially those containing xylitol, may be effective in treating dry mouth. Examples of mouthwashes that are effective in moisturizing the mouth include:

Biotene Dry Mouth Oral Rinse or Act Dry Mouth.

3. In cases of severe dry mouth resulting from Sjögren's syndrome or radiation therapy for head and neck cancer, the doctor may prescribe pilocarpine (Salagen) to increase saliva production. Or he may prescribe cevimeline (Evoxac) to increase saliva secretion in the event of Sjögren's syndrome.

Imaging of salivary gland

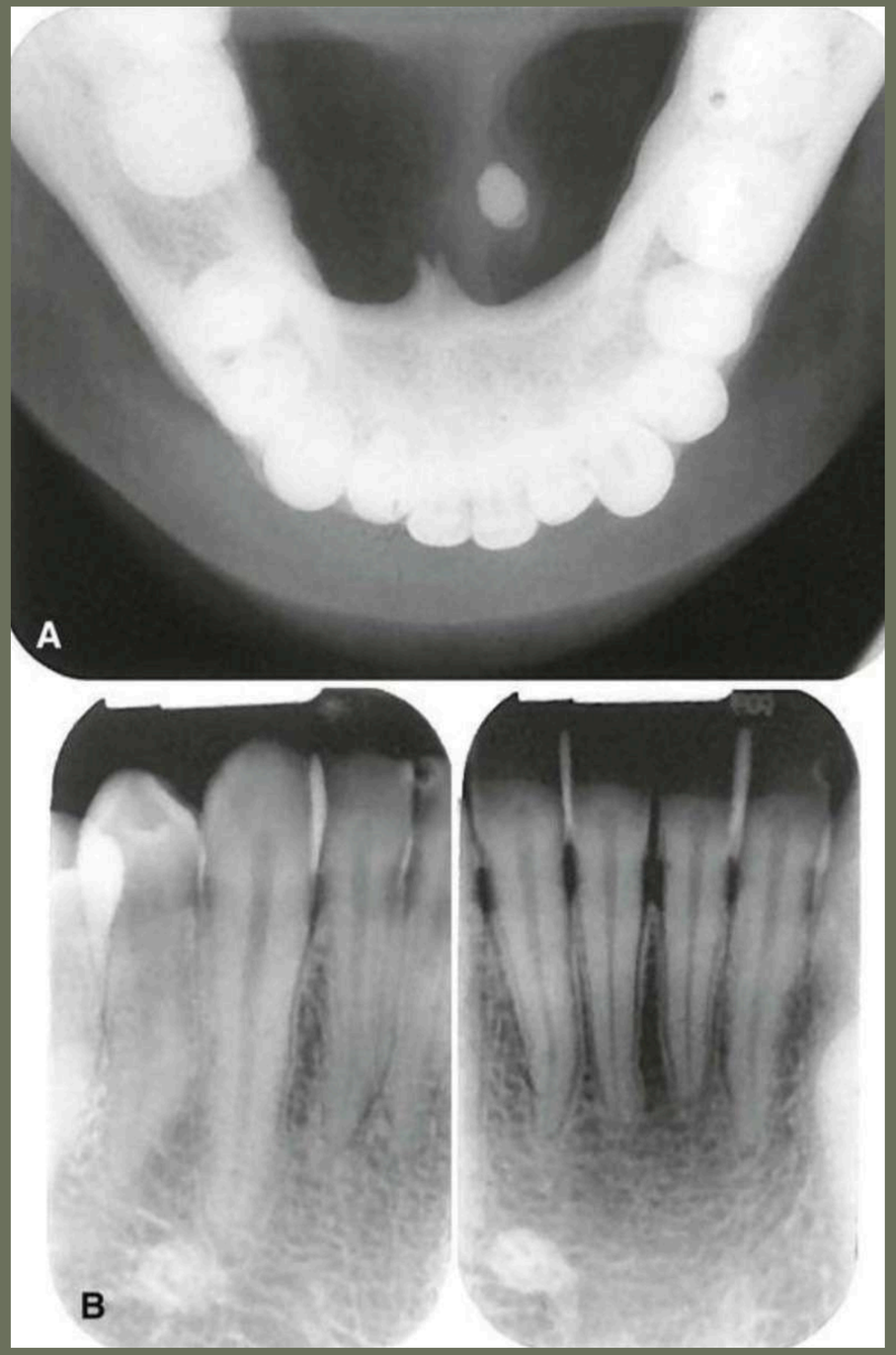
A - Diagnostic Imaging

Imaging is often used to diagnose and to plan management and follow-up of patients with salivary gland disorders. It provides crucial information regarding the nature of the disease affecting the salivary glands, the extent and severity of glandular involvement, and the effect on the surrounding structures.

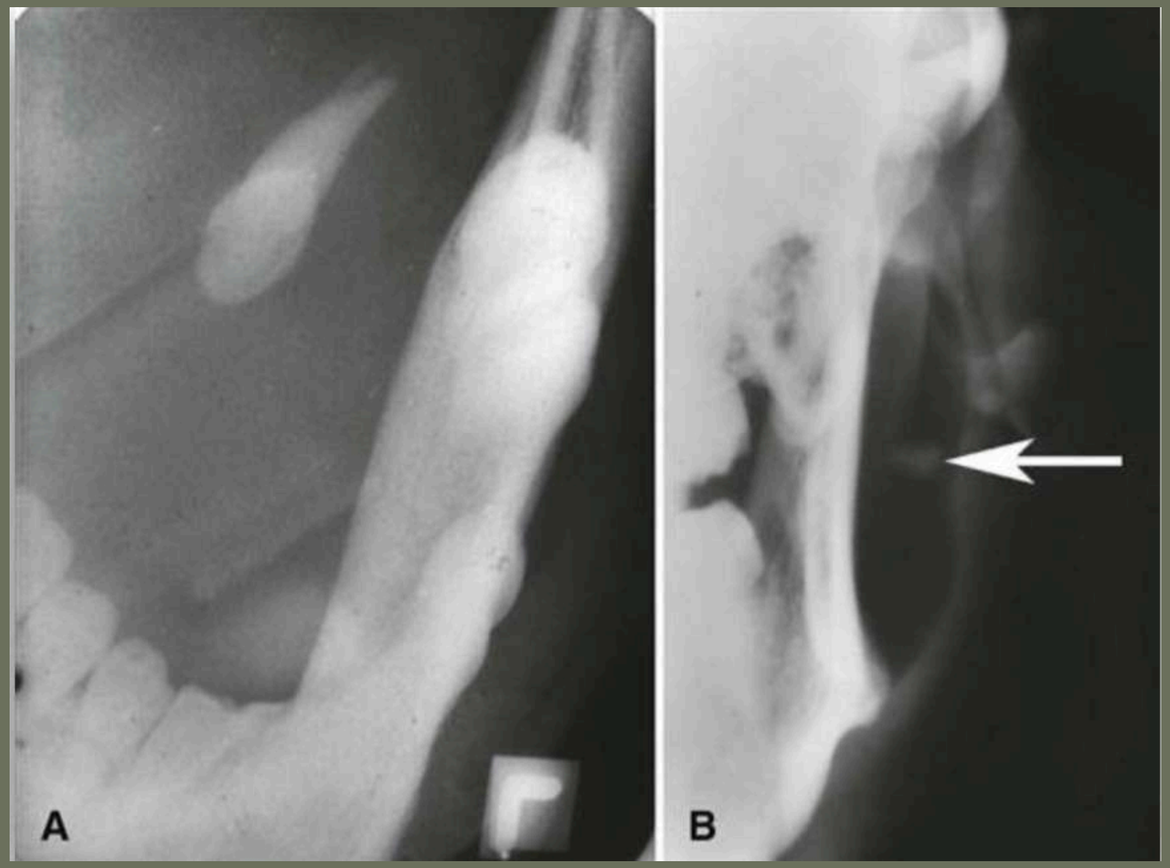
B- Projection imaging

Projection or plain radiography is the simplest, oldest, and cheapest way of studying the salivary glands., whether intraoral occlusal images or extraoral panoramic images, It is useful in detecting ductal calculi, calcifications (as in hemangioma and lymph nodes), and adjacent osseous lesions.
Crosssectional mandibular occlusal images are best used to identify submandibular duct sialoliths, whereas panoramic images may be used to demonstrate both parotid and submandibular sialoliths.

Some of the advantages of projection images are that they are readily available, are inexpensive, and subject the patient to a relatively low dose of radiation. In addition, they allow examination of osseous structures adjacent to the salivary glands projection images do fail at identifying noncalcified sialoliths, which are estimated to account for 40% of all parotid sialoliths and 20% of all submandibular sialoliths

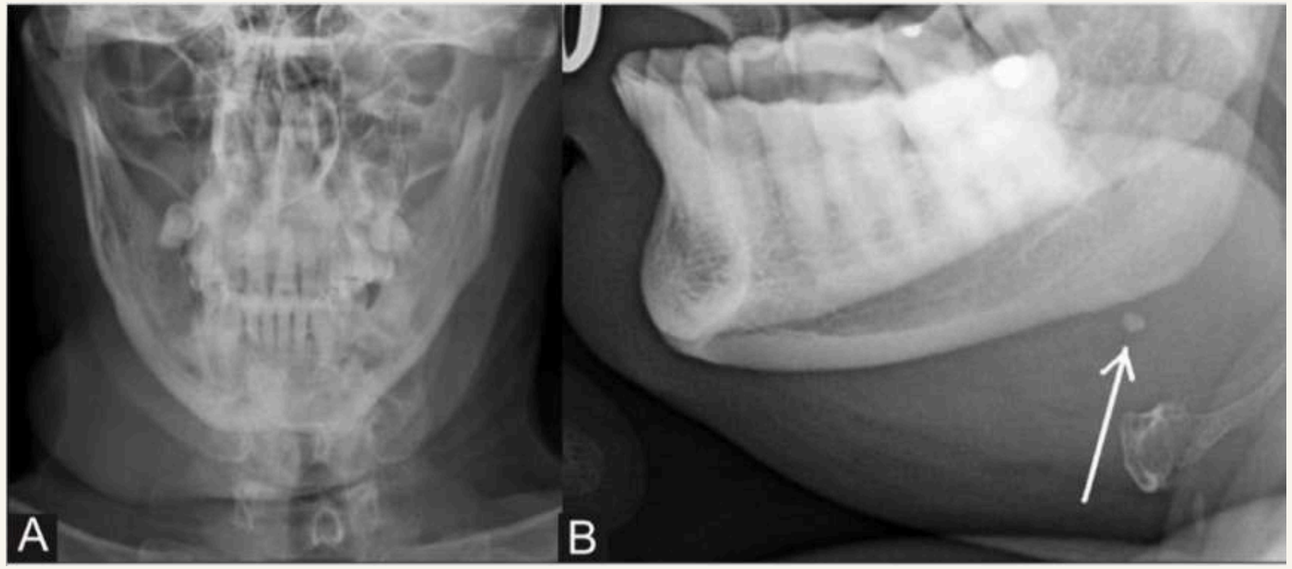


Intraoral radiographic projections. A, Underexposed mandibular occlusal radiograph demonstrates a radiopaque sialolith in Wharton's duct. Note the classic laminated appearance. B, Periapical radiographs of the same case. The radiopaque calculus can be localized lingual to the teeth by applying appropriate object localization rules.



Extraoral radiographic projections. A, Over-the-shoulder occlusal projection reveals a sialolith. B, Anteroposterior skull view with cheek blown out to provide air contrast to reveal a parotid sialolith (arrow).

Plain radiograph of the submandibular region in AP (A) and lateral oblique (B) projection showing soft tissue swelling associated with a small calculus (arrow) visible on lateral oblique view taken with depressed tongue



C- Magnetic Resonance Imaging

MRI is the imaging method of choice for assessment of space- occupying lesions (cyst and neoplasms) of the salivary glands because of its superior soft-tissue contrast. In addition, the use of intravenous gadolinium as a contrast agent makes MRI the imaging modality of choice for evaluation of intracranial and perineural spread of disease. Detection of sialoliths, particularly when calcified, is problematic in MRI because these calcific entities result in signal voids. Other disadvantages of MRI include long acquisition times, relatively poor spatial resolution, cost, and accessibility Magnetic resonance imaging (MRI) is known to allow multiplanar analysis of soft tissues with high contrast resolution, being an excellent method for both salivary gland observation and for the diagnosis of various glandular disorders, allowing the three-dimensional analysis of the extension of a lesion and its relationship with adjacent anatomical structures.

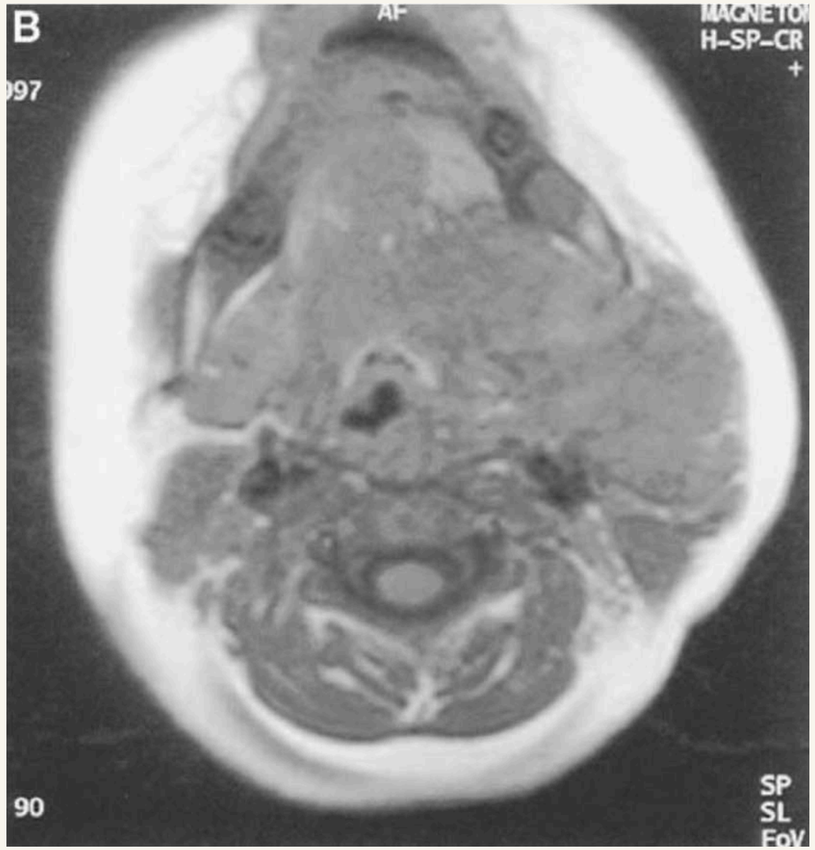
- **Branchial cleft cyst**

On MR imaging brachial cleft cysts demonstrate low T1 and high T2 signals and appear as single fluid-filled masses. There is generally no thickening or enhancement of the surrounding rim; however, when infected or having a previous history of infection, thickening and enhancement of the surrounding rim can be present.

(A) T2-weighted axial MR image shows a single rounded cystic lesion with high T2 signal within superficial lobe of right parotid gland.

(B) Post-gadolinium imaging shows a nonenhancing low T1 signal area.

Cystic hygroma



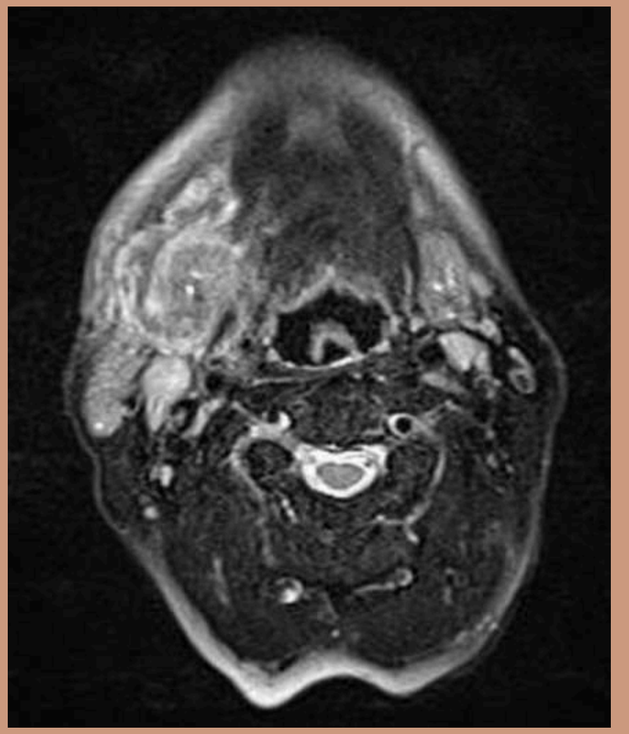
(B) T1-weighted axial image shows enlargement of left parotid with intermediate T1 signal.

(C) T2-weighted axial image shows high T2-signal cystic mass at left parotid gland.

•Sialoadenitis

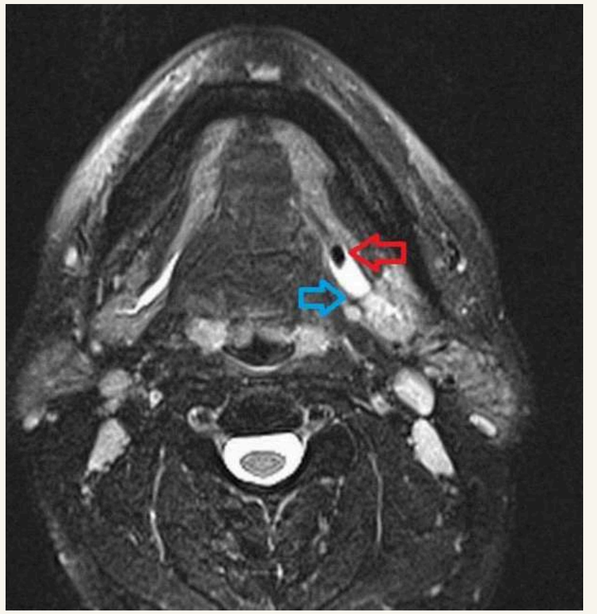
On MR imaging the gland might appear to be enlarged and exhibit abnormally high T2 intensity or attenuation and enhance intensely . There is a general thickening of deep and superficial fascia and infiltration of subcutaneous fat. Fascial thickening of deep cervical fascia and infiltration of cervical fat produces a "dirty fat" appearance.

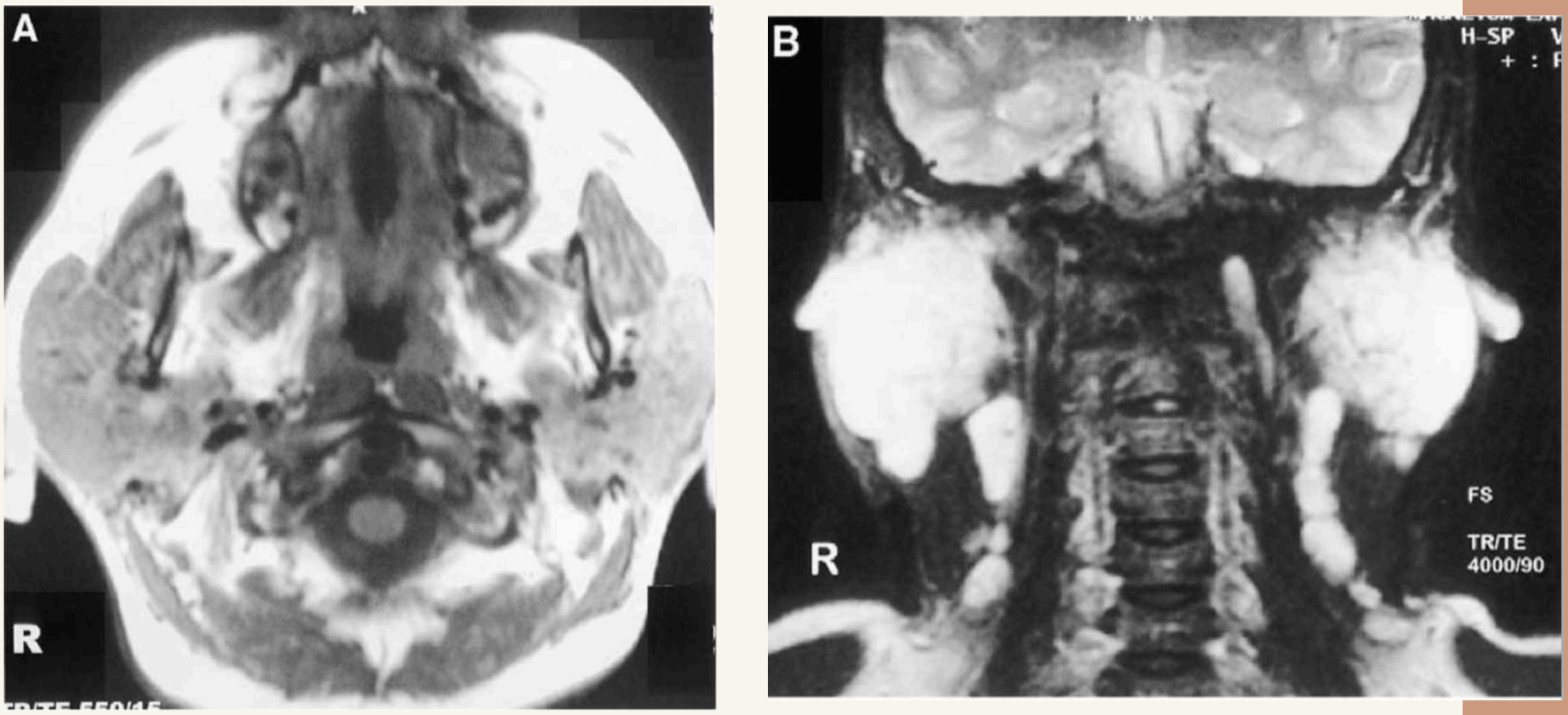
Chronic inflammation results in shrinkage of the gland. On MR imaging, the gland exhibits low T1 and low T2 signals.



•Sialolithiasis

Sialolithiasis is second most common inflammatory disease of the salivary glands after mumps. On MRI Fast T2-weighted MR imaging with thin sections is proposed for evaluation of ductal architecture, although tiny calculi within the gland and larger duct might not be detected on MR imaging due to signal void associated with a stone.





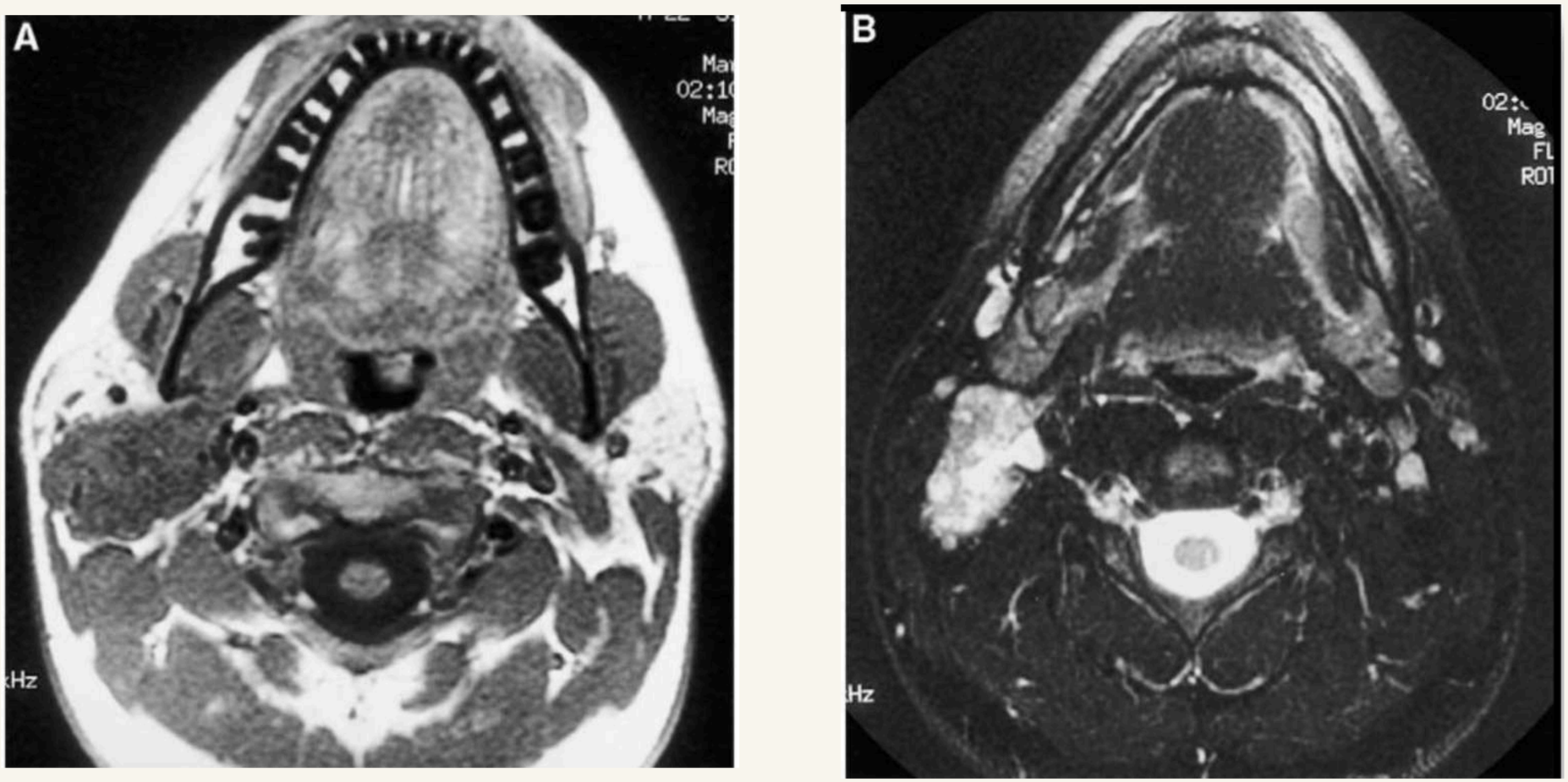
Sjogren's syndrome with lymphoma.
(A) T1 axial MR imaging shows diffuse enlargement of bilateral parotid glands. (B) T2 coronal MR image shows a high signal at enlarged parotid glands

•Benign tumors exhibit smooth, well-defined borders and homogeneous enhancement on CT and MR imaging. Evaluation of the shape, margin, internal architecture, capsule-like lining of the mass, possible infiltration of surrounding tissue planes, and lymph nodal involvement are important parameters for evaluation of a salivary gland mass with MR imaging. High-grade and aggressive malignancies tend to have low to intermediate signals on T2- and T1-weighted imaging, differentiating them from other tumors of the parotid glands. This is because with higher cellularity, overall water content would be low. A majority of parotid tumors are either benign or low-grade neoplasms, however. MR imaging is useful in delineating malignant tumors but it is not considered to be reliable in predicting the histologic nature of a parotid mass .

• Warthin's tumor

On MR imagingappears to be a well circumscribed lobulated mass, mainly in the tail of the parotid gland. It appears to have intermediate signal on T1-weighted and a high signal on T2-weighted images with frequent cystic transformation

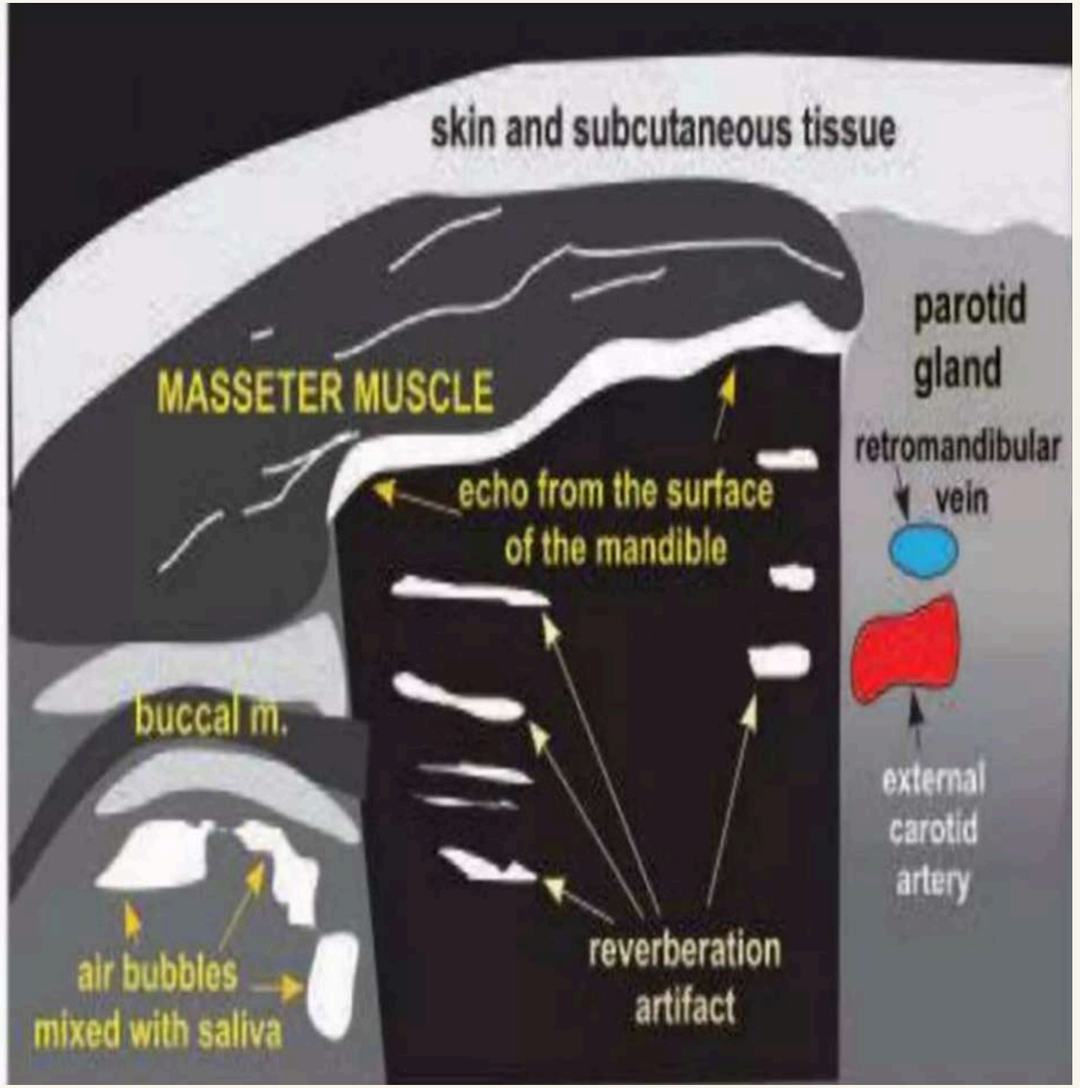
•parotid gland tumors On MR imaging, appear relatively well defined and have high T2 signals due to higher water content.



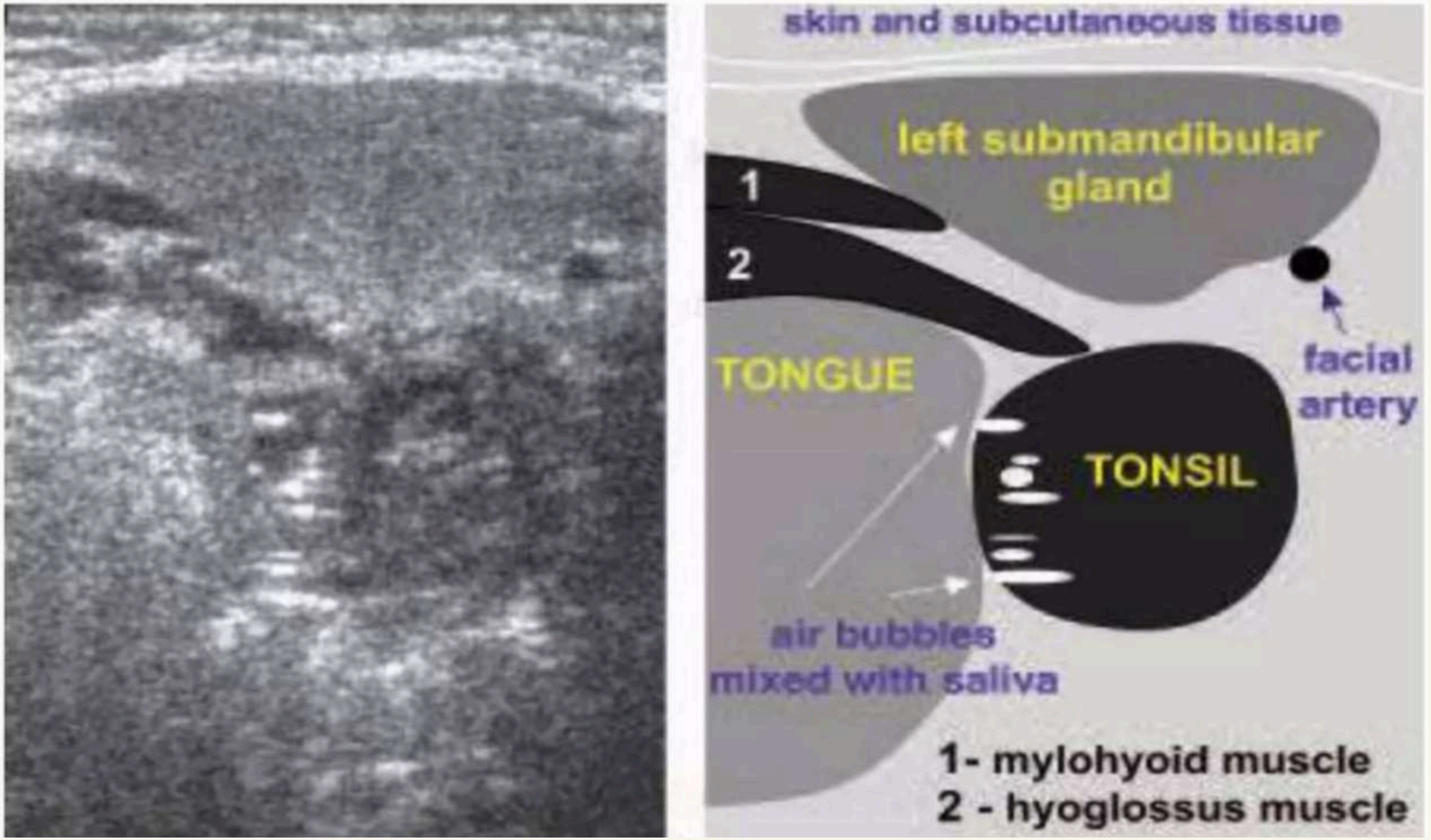
Adeno cystic carcinoma. (A) T1-weighted axial MR image shows lobulated primarily low signal mass in the right parotid gland extending into the deep lobe. (B) Fat suppressed T2 axial MR image shows the lesion to be heterogeneously hyperintense with a few markedly bright areas.

D-High resolution Ultrasonography

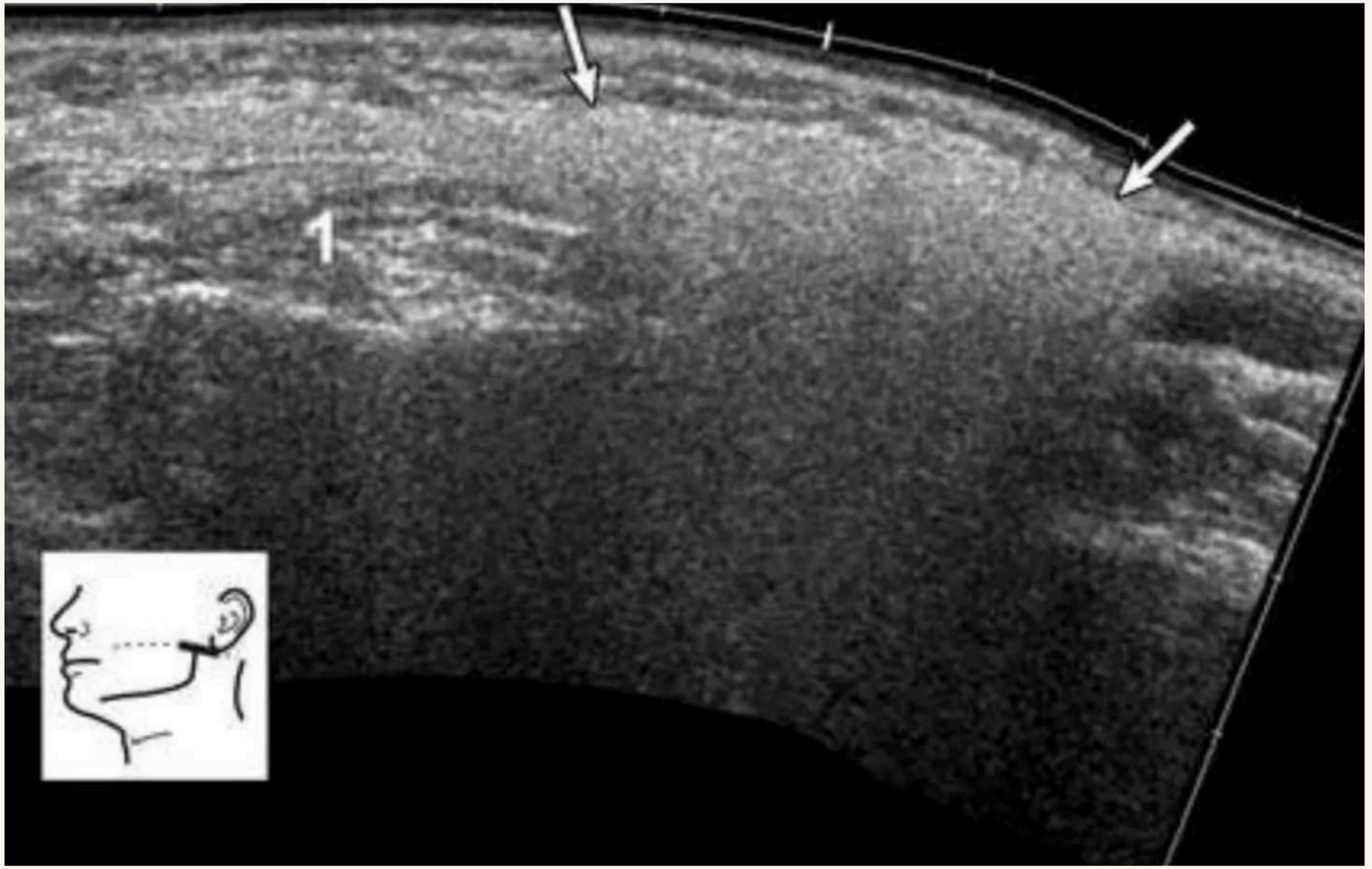
It is a quick and noninvasive method of evaluating parotid and submandibular glands, used for the initial assessment especially when an abnormality is located superficially It may also be used to guide biopsies and also aids in guiding the exact site of Fine Needle Aspiration Cytology (FNAC) in suspected salivary gland lesions. HRUS is helpful at differentiating cysts from solid lesions, and benign from malignant lesions . HRUS has become more specific at detecting Sjögren syndrome, but it is still lacking in its ability to detect sialoliths. The major disadvantage of HRUS lies in its inability to detect deep salivary gland lesions, whereas its major advantage is its relative safety because it does not use ionizing radiation.



Parotid gland



Submandibular gland



Transverse panoramic US image of the left parotid gland (arrows) and cheek shows that the gland has a high fat content.

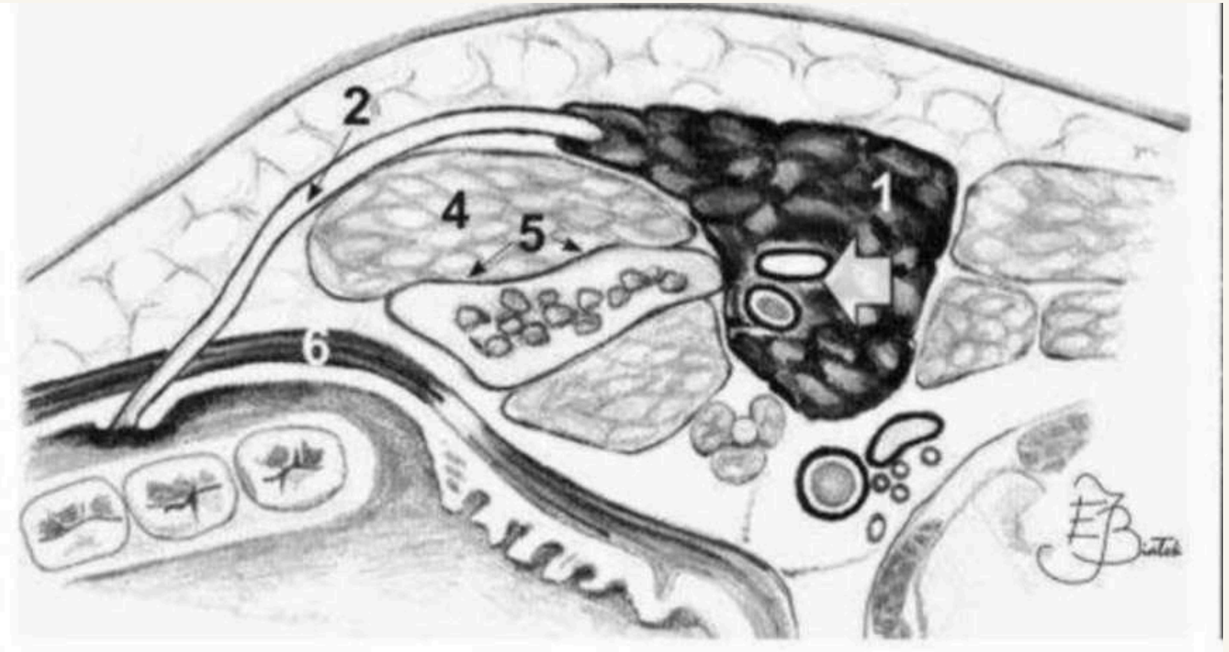
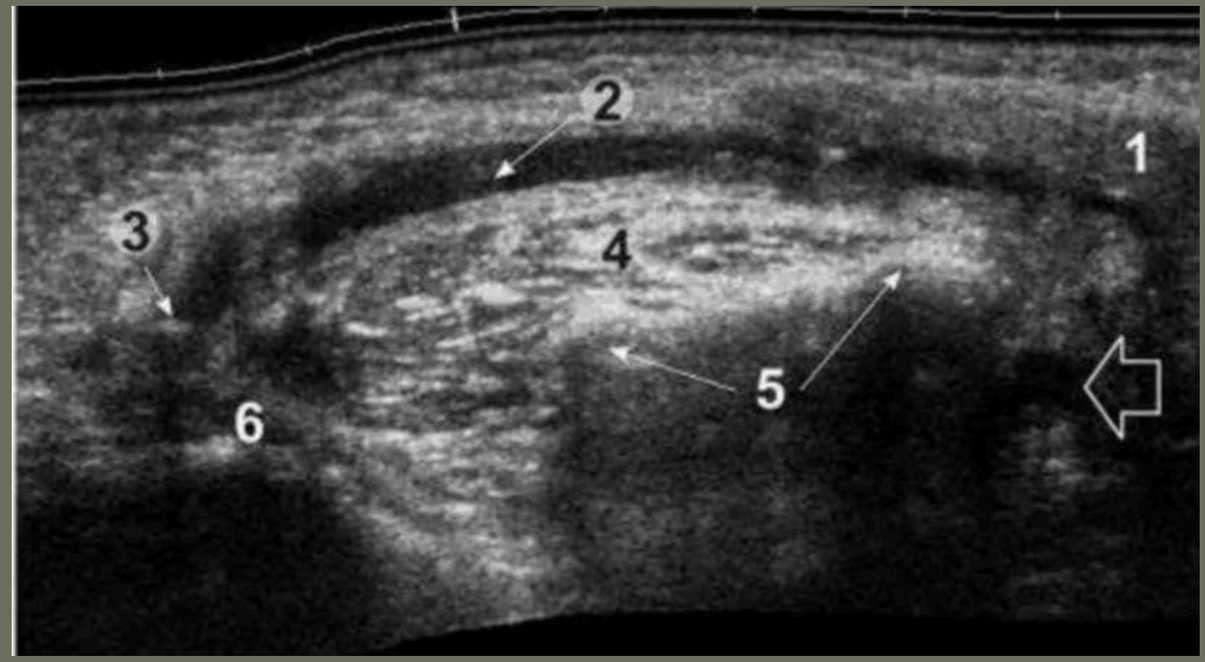
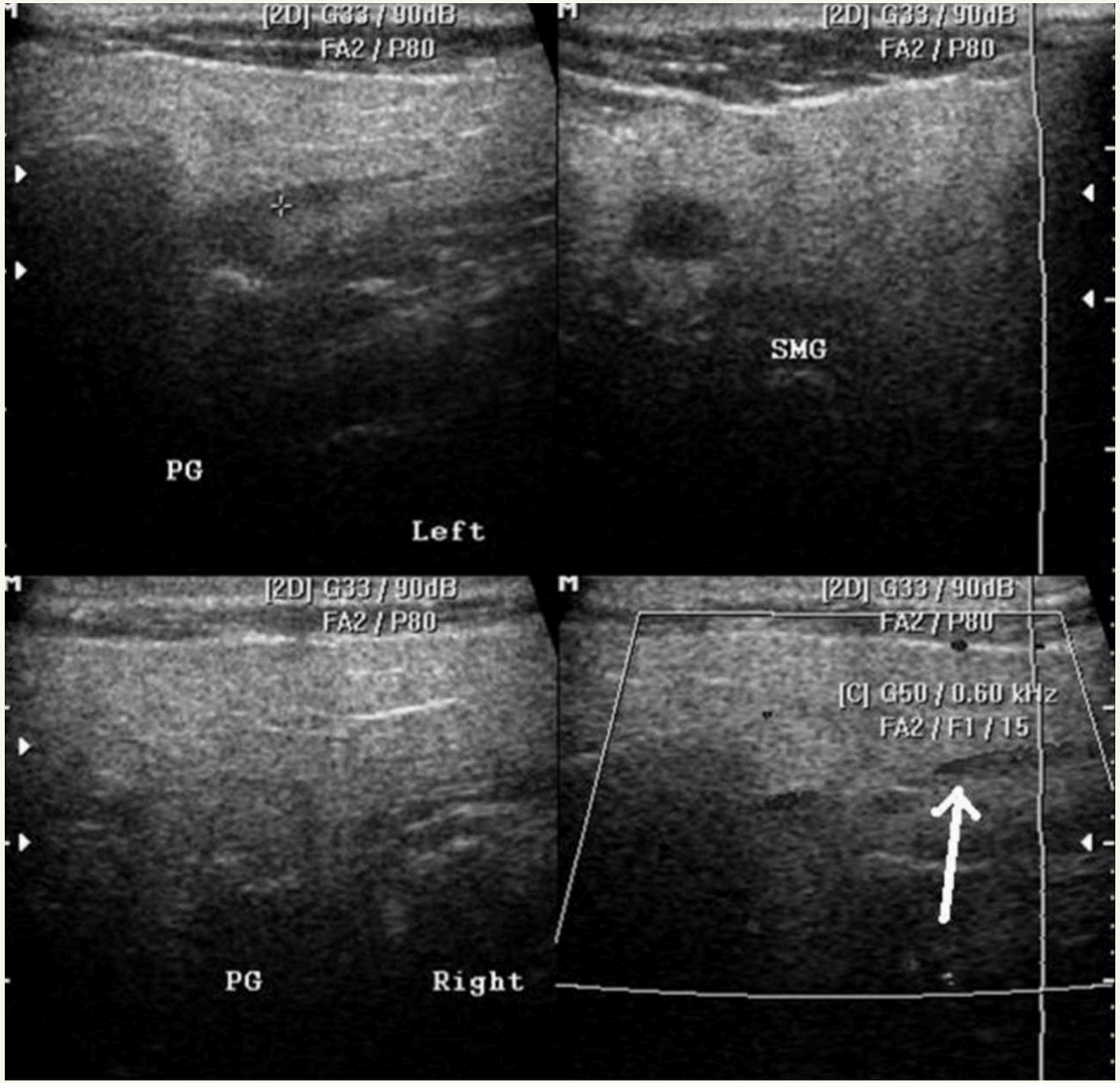


Diagram shows the location of the Stenon duct.
1 parotid gland, 2 Stenon duct, 4 masseter muscle, 5 surface of the mandible, 6 buccal muscle, large arrow retromandibular vein and external carotid artery.

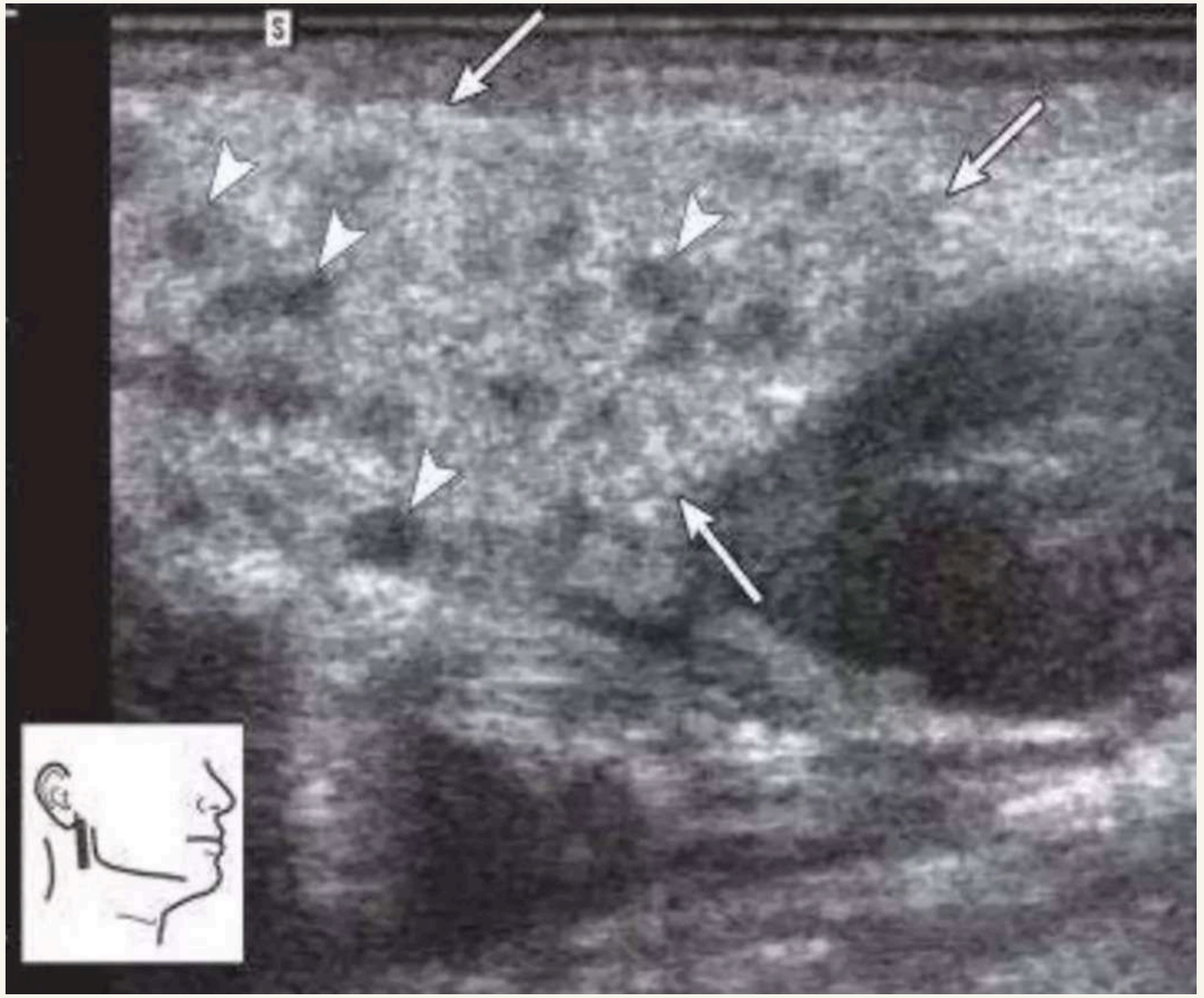


Panoramic US image shows a dilated Stenon duct in a patient with sialolithiasis and inflammation. 1 inflamed left parotid gland, 2 dilated Stenon duct, 3 stone,
4 masseter muscle, 5 surface of the mandible,
6 buccal muscle, large arrow retromandibular vein and external carotid artery.



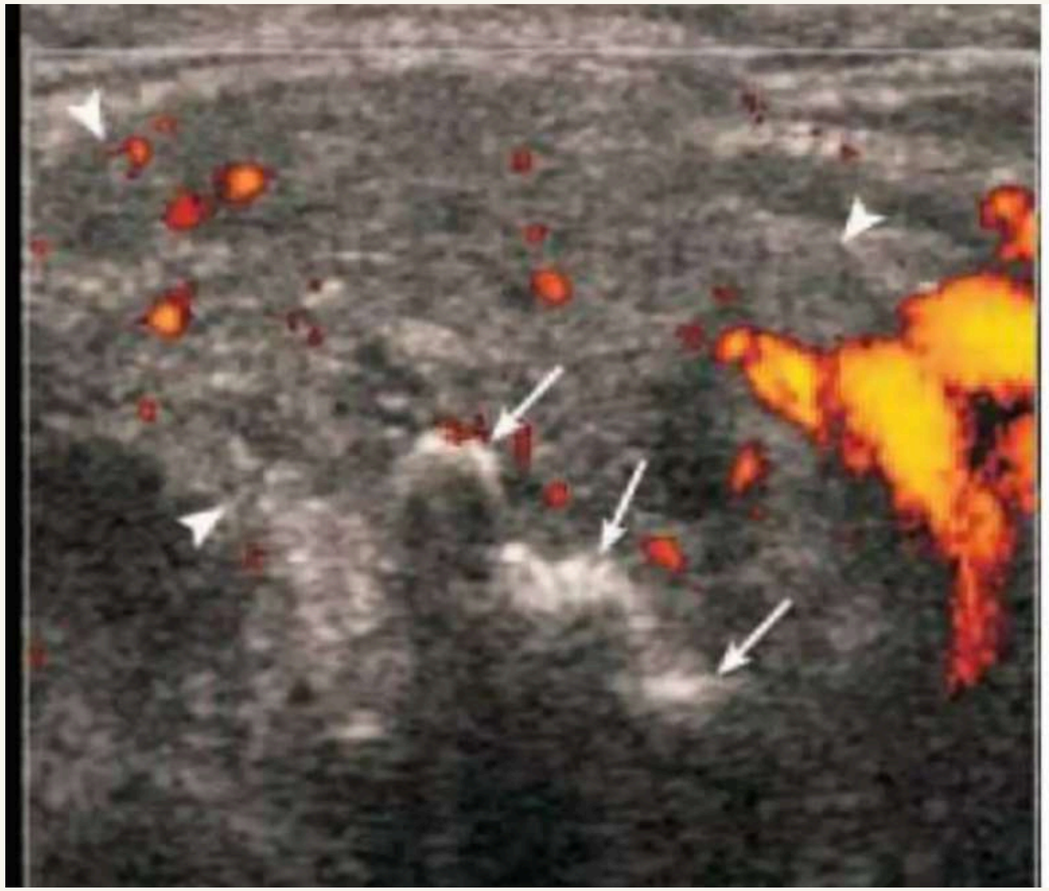
HRUS images showing normal parotid and submandibular glands (top row)
and
retromandibular vein in the parotid gland (arrow)

•In acute inflammation, salivary glands are enlarged and hypoechoic. They may be inhomogeneous; may contain multiple small, oval, hypochoic areas; and may have increased blood flow at US

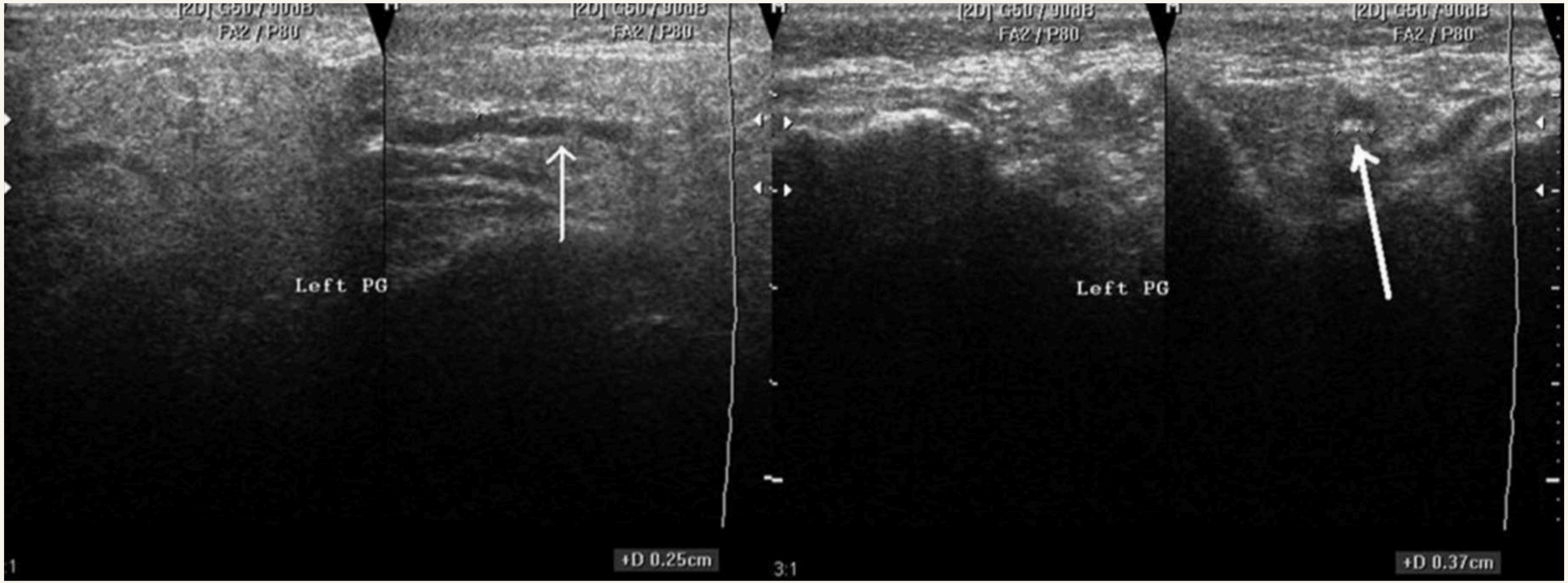


US image shows an acutely inflamed right parotid gland (arrows) in a 5-year-old child.

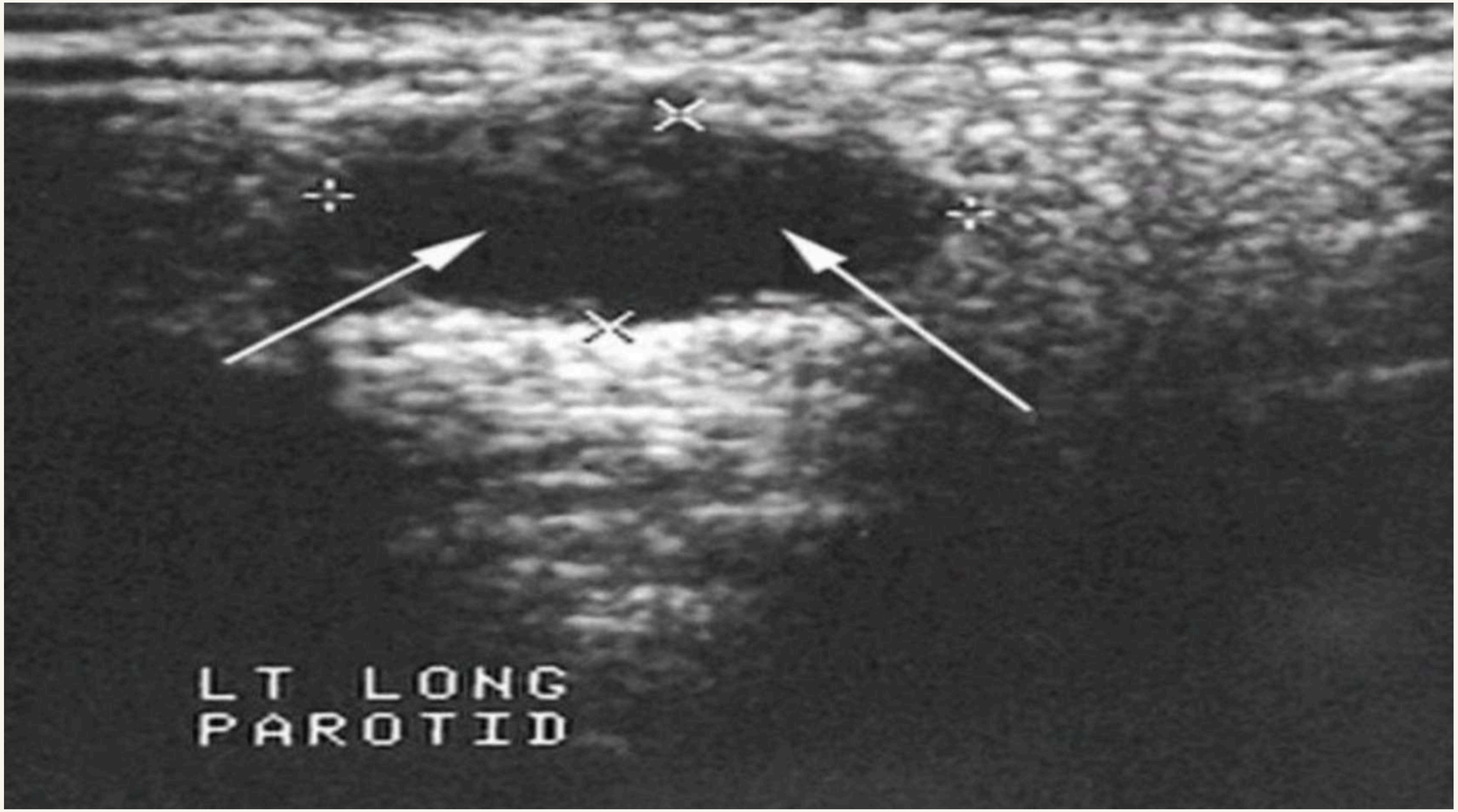
•Chronic sialadenitis is clinically characterized by intermittent swelling of the gland, often painful, that may or may not be associated with food.
In chronic inflammation, salivary glands are normal sized or smaller, hypochoic, and inhomogeneous and usually do not have increased blood flow at US.



chronic inflammation of the left submandibular gland (arrowheads).



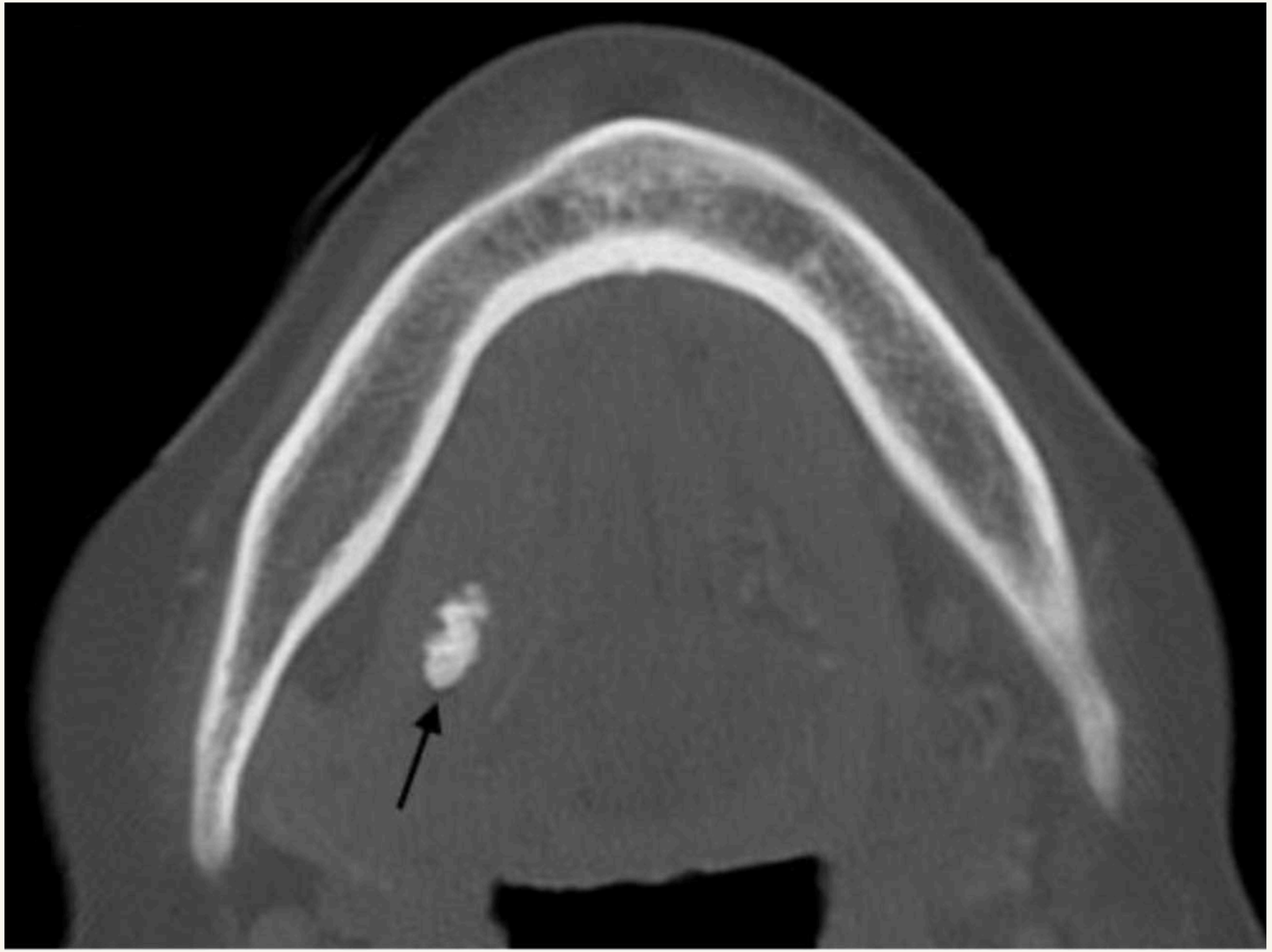
HRUS images show altered echopattern of the parotid gland with ductal dilatation (thin arrow) and small calculus (thick arrow) at its terminal end



High-resolution ultrasonography image of the parotid gland demonstrating an echo-free mass with well-defined margins, which is typical of a cystic mass (arrows).

E-Multidetector Computed Tomography MDCT

MDCT imaging is useful in evaluating structures in and adjacent to salivary glands, displayed in both hard- and soft-tissue windows, This is especially true when the images are acquired after intravenous administration of a contrast agent that renders glandular tissues hyperdense relative to the surrounding fat and muscle. The parotid glands are more radiopaque than the surrounding fat but less opaque than adjacent muscles. Although the submandibular and sublingual glands are similar in density to adjacent muscles, they are readily identified on the basis of shape and location.MDCT imaging is useful in assessing acute inflammatory processes and abscesses, cysts, mucoceles, and neoplasia. Calcifications such as sialoliths are also well depicted with MDCT imaging but only if they are relatively large and significantly calcified. Smaller, less-calcified sialoliths and ductal strictures are not well.



Axial bone algorithm MDCT image shows a sialolith in the submandibular (Wharton's) duct.

F-Computed Tomography (CT)

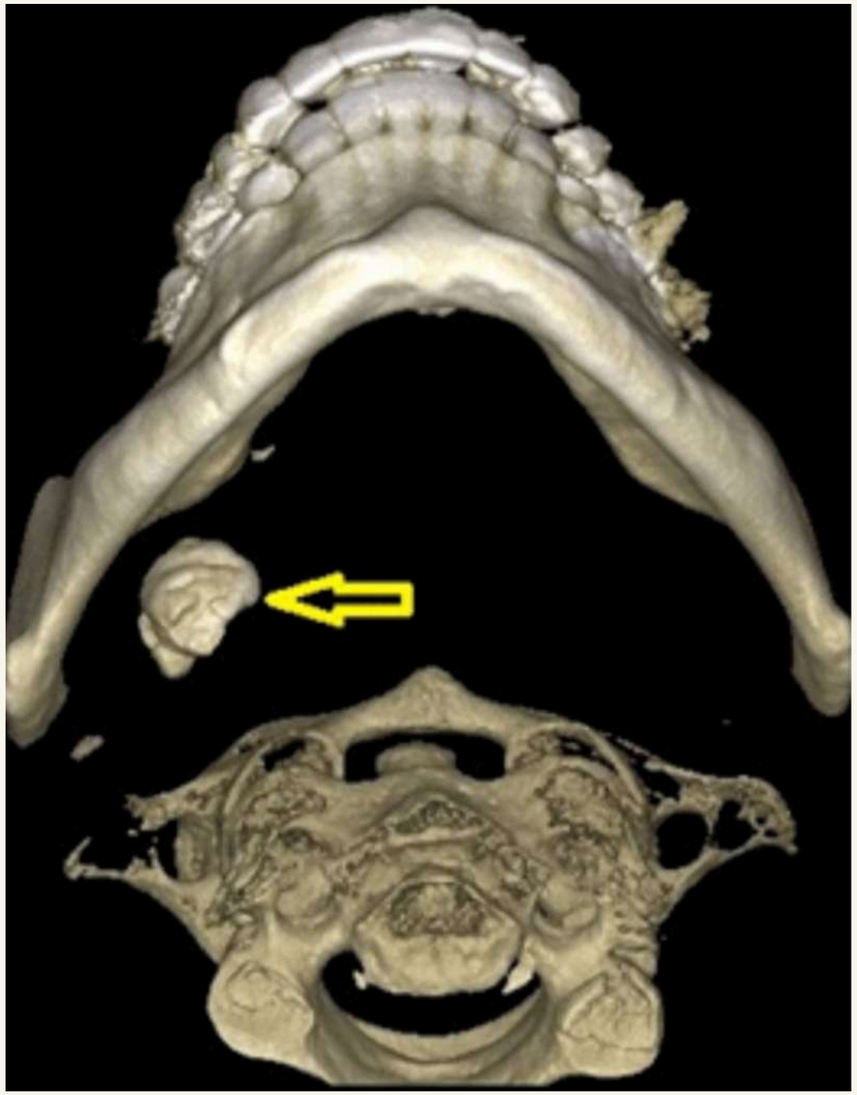
CT is the method of choice for the radiologic examination of masses in or about the salivary glands as well as for the study of diffuse noninflammatory enlargement of a salivary gland or glands. It is capable of producing clinically useful information that can be used directly to determine appropriate therapy. The major salivary glands appear hypodense than surrounding muscles. Coronal section in contrast enhanced CT is best view in visualizing of submandibular and sublingual glands. Imaging with CT helps in detecting acute inflammatory process, abscess, mucocele, cyst, Sialolith and benign and malignant neoplasms.

Also, CT is useful for patients with contraindication for MRI. CT is more readily available and of lower cost than MRI; however, its main disadvantage is the high dose of radiation involved. CT is less invasive than conventional sialography because it can usually be performed without contrast material, and it is more sensitive in determining the presence or absence of a mass as well as its extent and whether it has arisen from within or outside of a salivary gland.

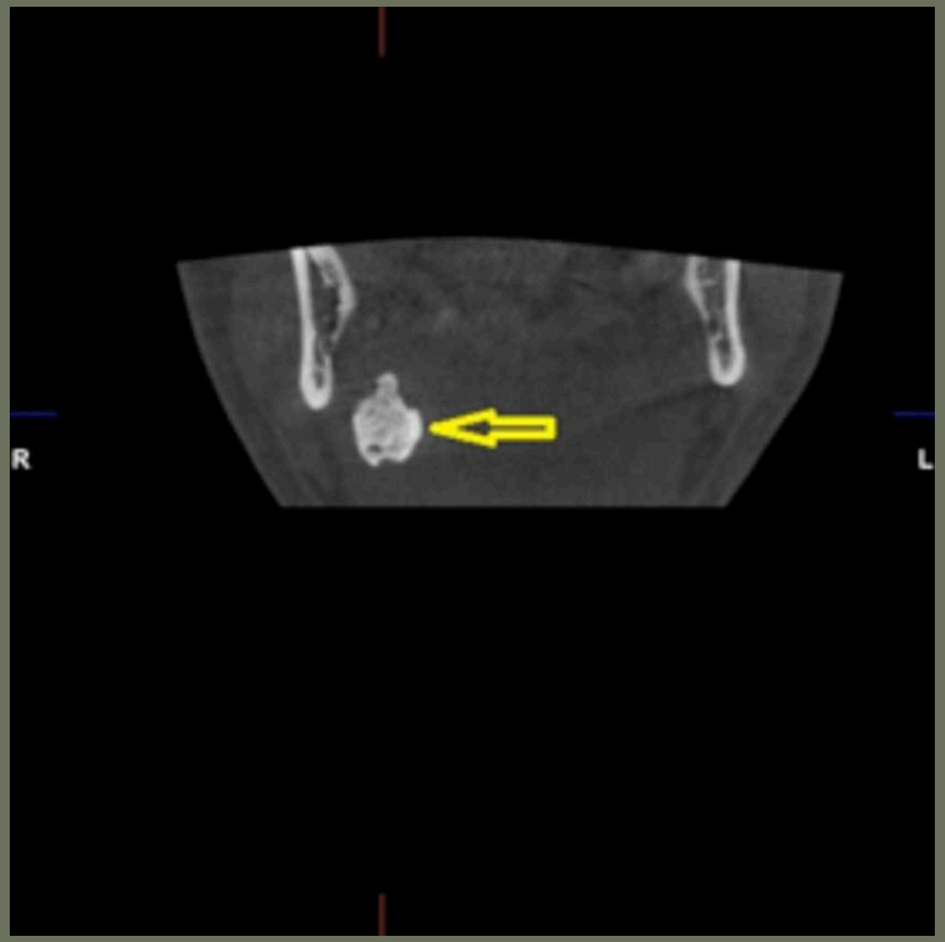
F-Computed Tomography (CT)

It provides exquisite anatomic detail, demonstrating the precise location of a mass within the parotid gland, from which its probable impact on the position of the facial nerve may be inferred information that is useful to the surgeon and that is especially well displayed in the axial projection. CT demonstrates whether a mass is circumscribed or invasive and sometimes can even demonstrate the precise histologic nature of a pathologic process, for example, lipoma, cyst, sialosis, or masseter muscle hypertrophy. Some caveats are in order. It should be remembered that CT is not a histologic method27 and can differentiate between a benign tumor and a malignant one only if there is obvious infiltration into the gland at the margins of the tumor or invasion outside the gland into the surrounding structures.

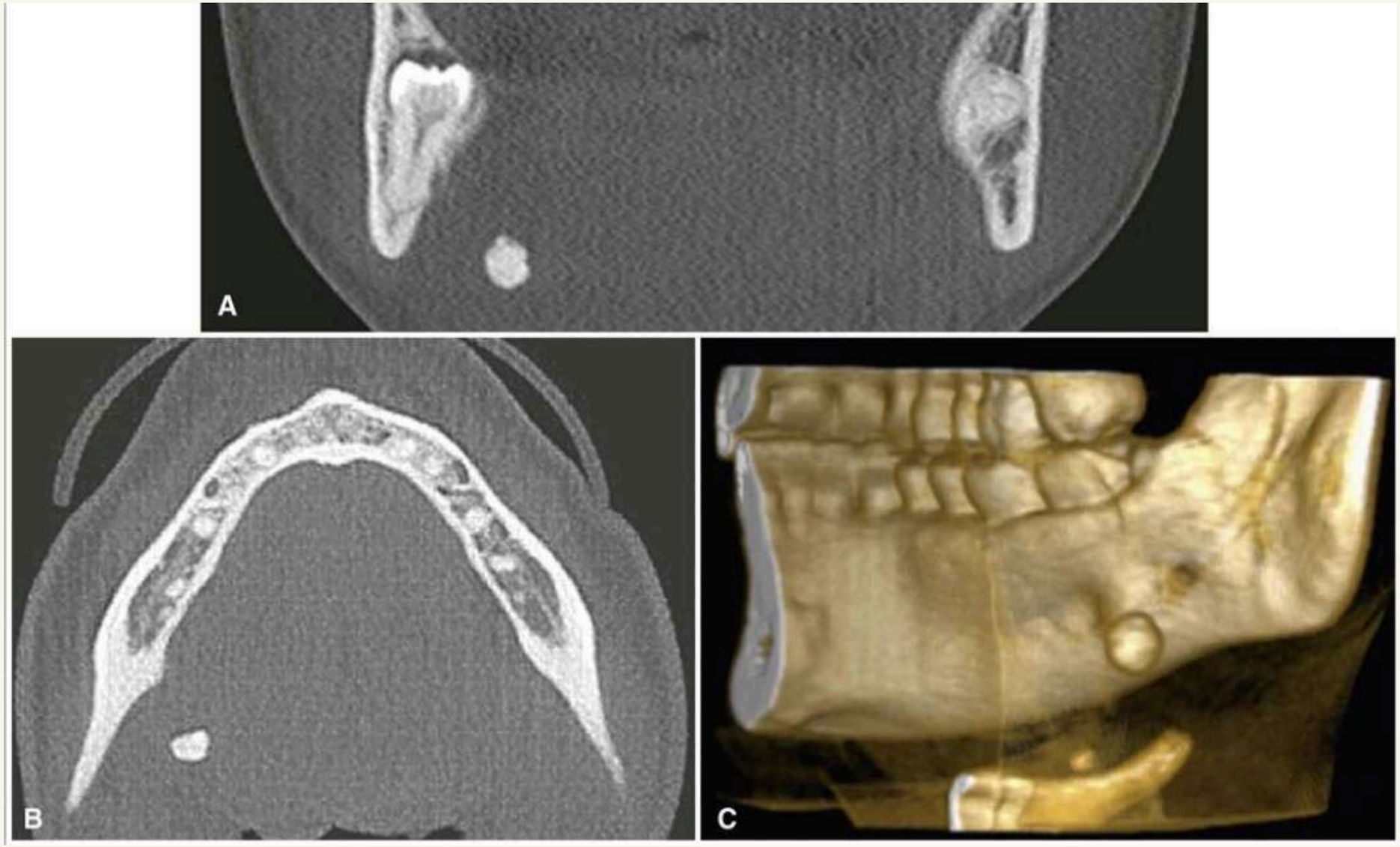
Furthermore, CT is not able to distinguish between a focal inflammatory process and a tumor. Nevertheless, sensitivity in the detection of salivary gland lesions may approach 100 per cent.According to Bryan and colleagues the specificity of the CT findings alone in distinguishing between benign and malignant neoplasms and inflammation is only about 75 per cent, although it may reach 90 per cent when the radiologic findings are integrated with clinical and laboratory data.



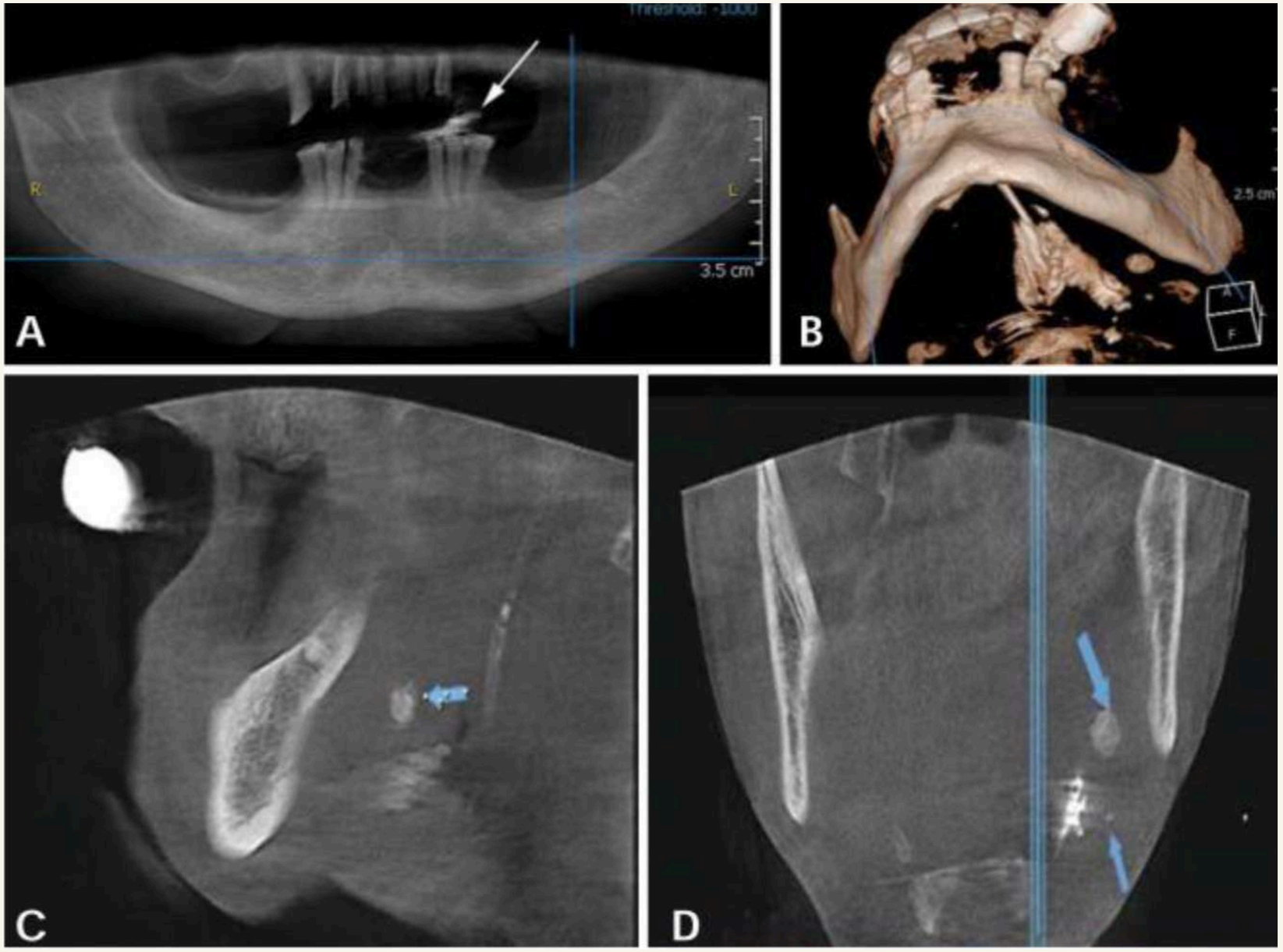
CBCT 3D reconstruction shows the position of giant right Submandibular Sialolith



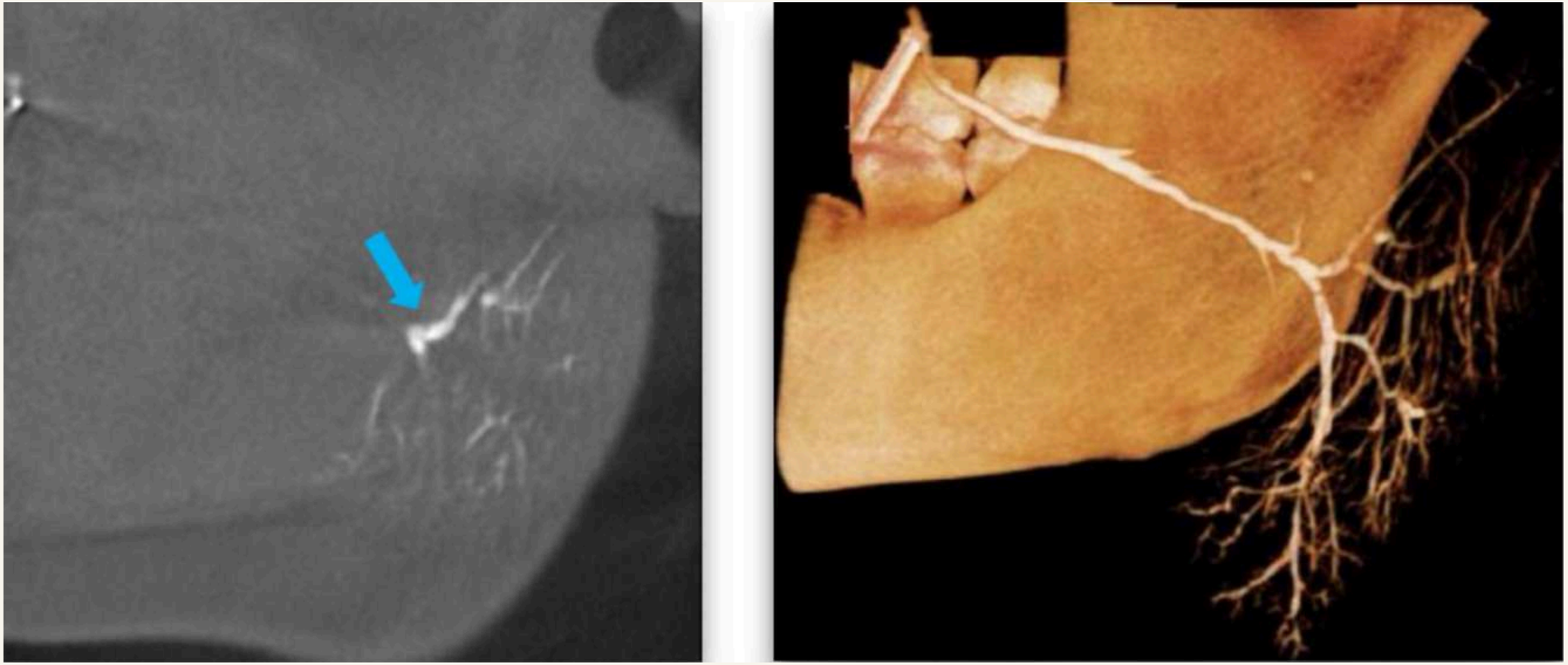
Coronal section of CBCT showing Right Submandibular sialolith



CBCT imaging of a submandibular sialolith. Coronal (A), axial (B), and three-dimensional renditions (C).



Panoramic (A), 3D reconstruction (B), sagittal (C), and coronal (D) images of CBCT with large and small stones in the submandibular gland (arrows).



Corrected sagittal cone beam CT
image of the parotid gland showing mild dilatation of the primary and secondary ducts as indicated with the blue arrow (left). A 3-dimensional volume rendering of the same case (right).

CT vs CBCT

CBCT	CT
Single rotation	Multiple rotation
Isotropic voxels	Anisotropic voxels
Lower radiation dose	Higher radiation dose
Lower cost	Higher cost
Smaller space requirement	Larger devices
Spatial resolution	Better contrast resolution
Deficiency to display soft tissues	Clear evaluation of soft tissue
Higher scatter radiation	Lower scatter radiation

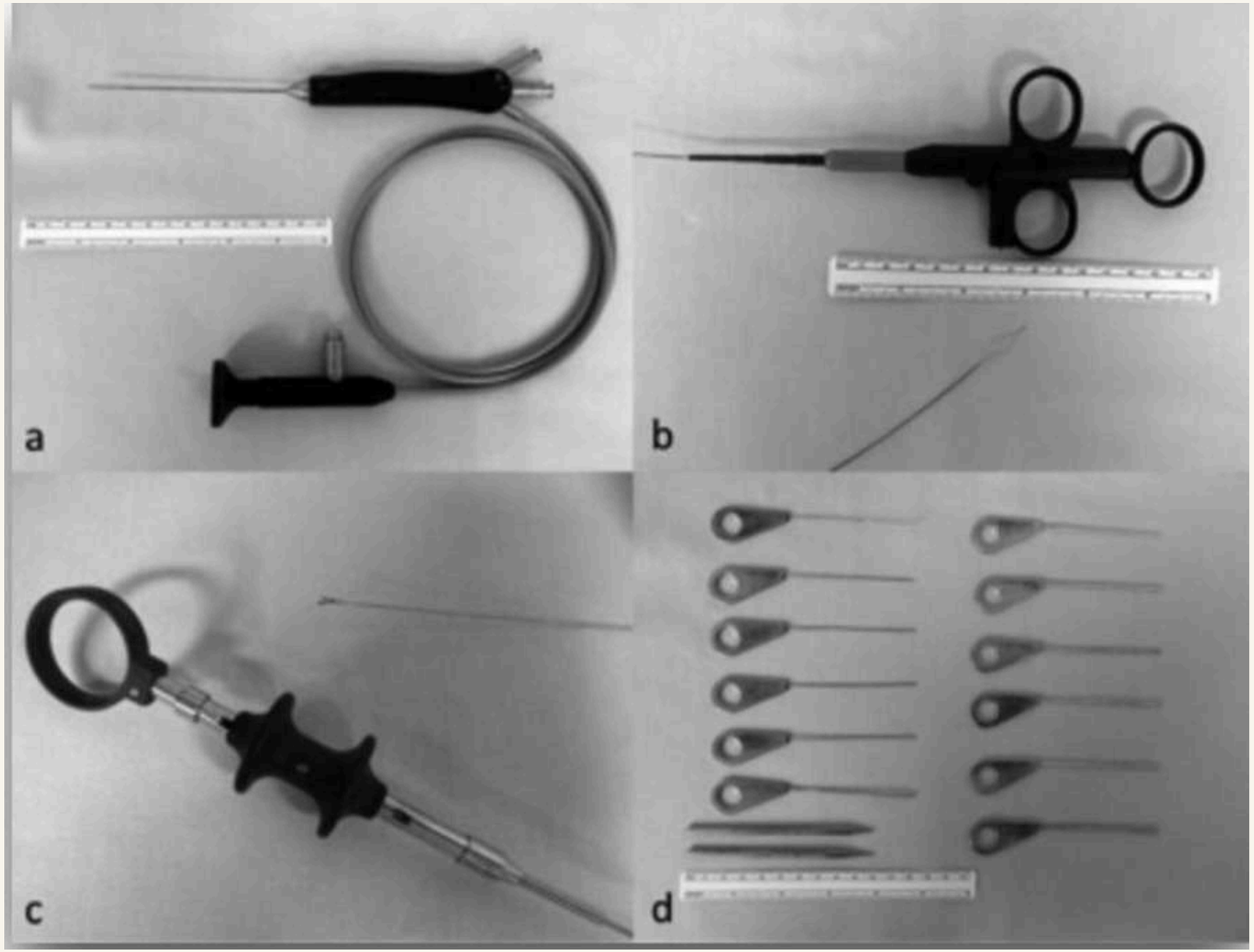
	Fan Beam CT	Cone Beam CT
CT Generation	3rd	3rd
X-ray beam shape	Fan beam	Cone beam
Detector type	X-axis only	X and Y-axis
Volume acquisition requirements	Multiple gantry rotations	Single gantry rotation (potentially)
Examination speed	Fast*	Fastest

*compared to single slice axial CT

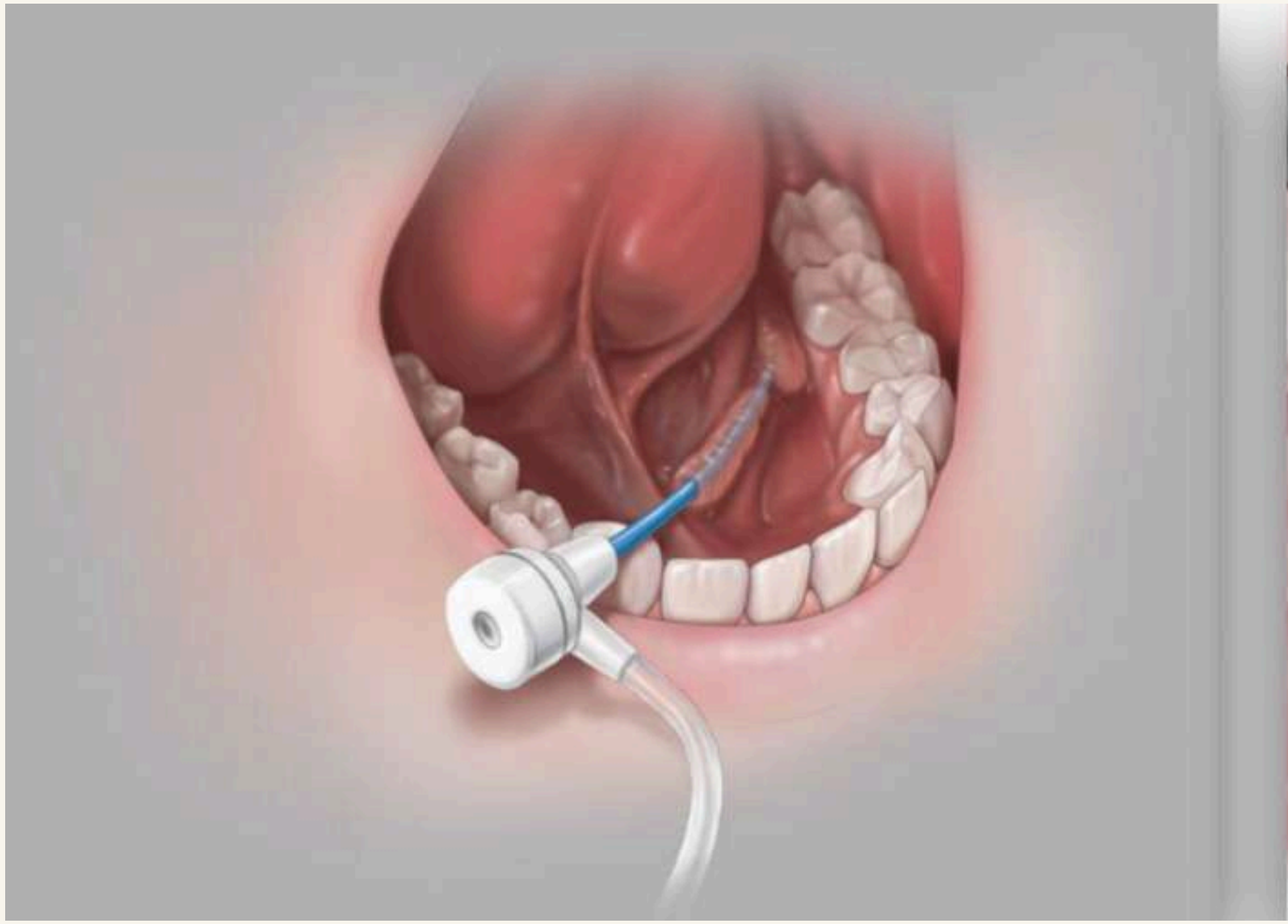

Right Floor
Mouth Ranula
Early Ranula
Left Floor
Mouth

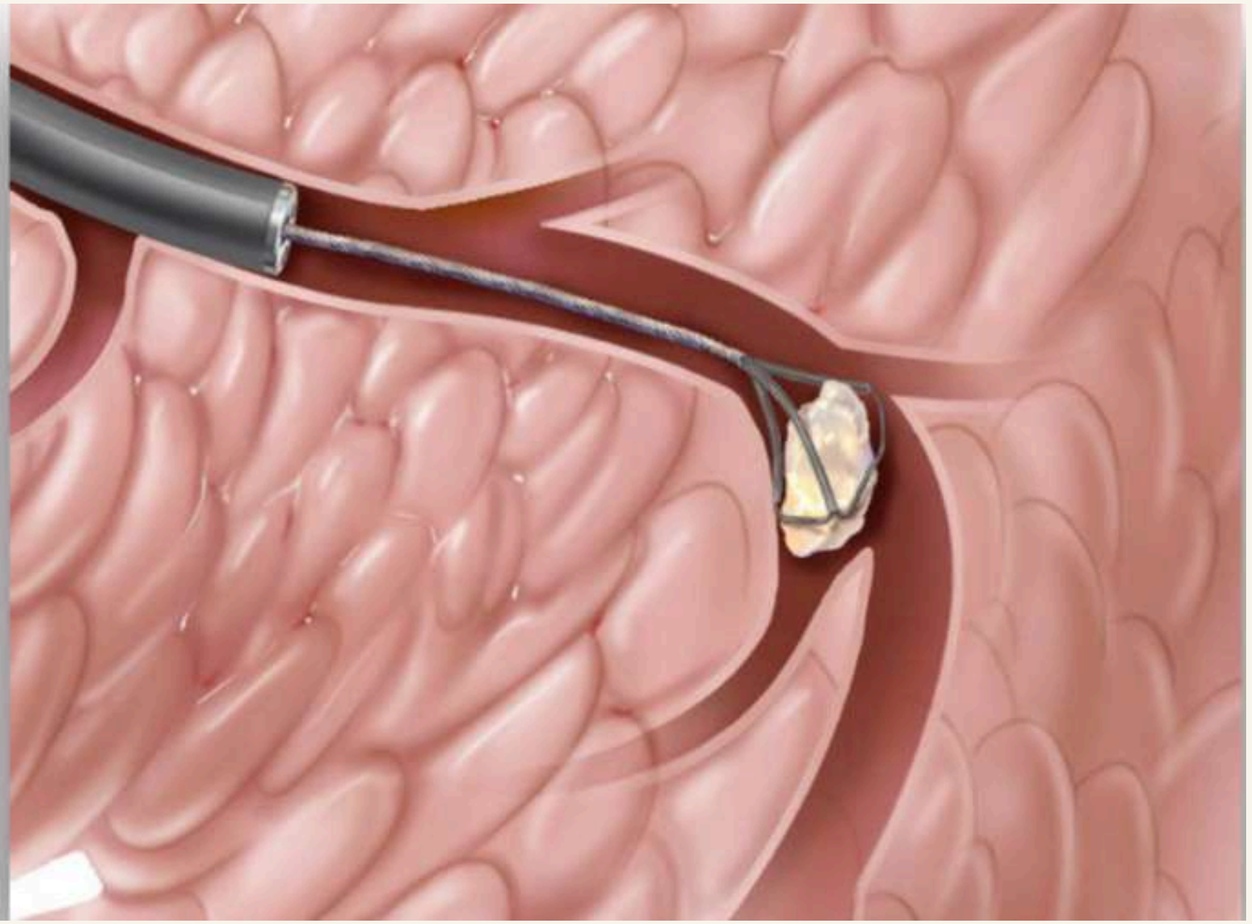
G-Sialendoscopic

Latest edition in imaging modalities of Salivary glands, this method uses Fiberoptic endoscopic principles in salivary gland. In this method the sialendoscope is inserted in major salivary gland duct opening to visualize live ductal and glandular condition. In addition to diagnose the condition it also helps in intervention in form of irrigation, medication delivery, lithotripsy and use of basket to remove the smaller Sialoliths [9]. A specialized, very narrow endoscope called a micro-endoscope provides a lighted view of the inside of the gland. The micro-endoscopes range from 0.8 to 1.6 millimeters in width. This micro-endoscope outfitted with a light, a camera and tools. Tiny baskets and small graspers can extract very small salivary stones. Other tools can help the doctor dilate blockages such as strictures of the salivary is duct. Complete recovery after a sialendoscopy procedure usually takes only a week or so. Follow your doctor's instructions, which may include avoiding any heavy lifting or straining. You may be instructed to take an over-the-counter anti-inflammatory medicine, or you may get a prescription for an alternative.



Sialendoscopic instruments. a: Compact semi-rigid endoscope with 0.4 mm working channel. b: Four wire basket. c: Forceps. d: Progressive salivary probe and conic dilatator





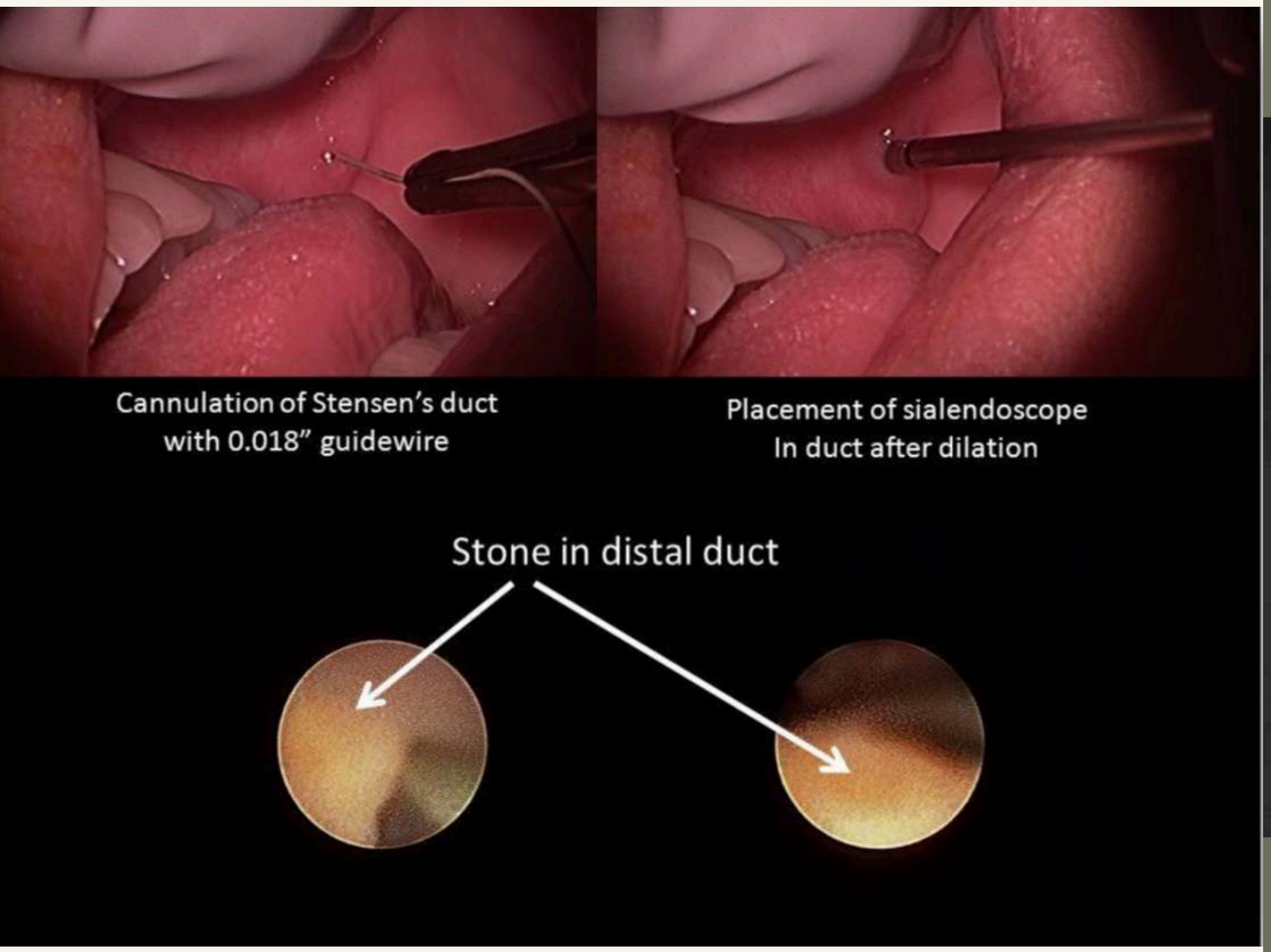
H- Radiation-Induced Salivary Gland Damage

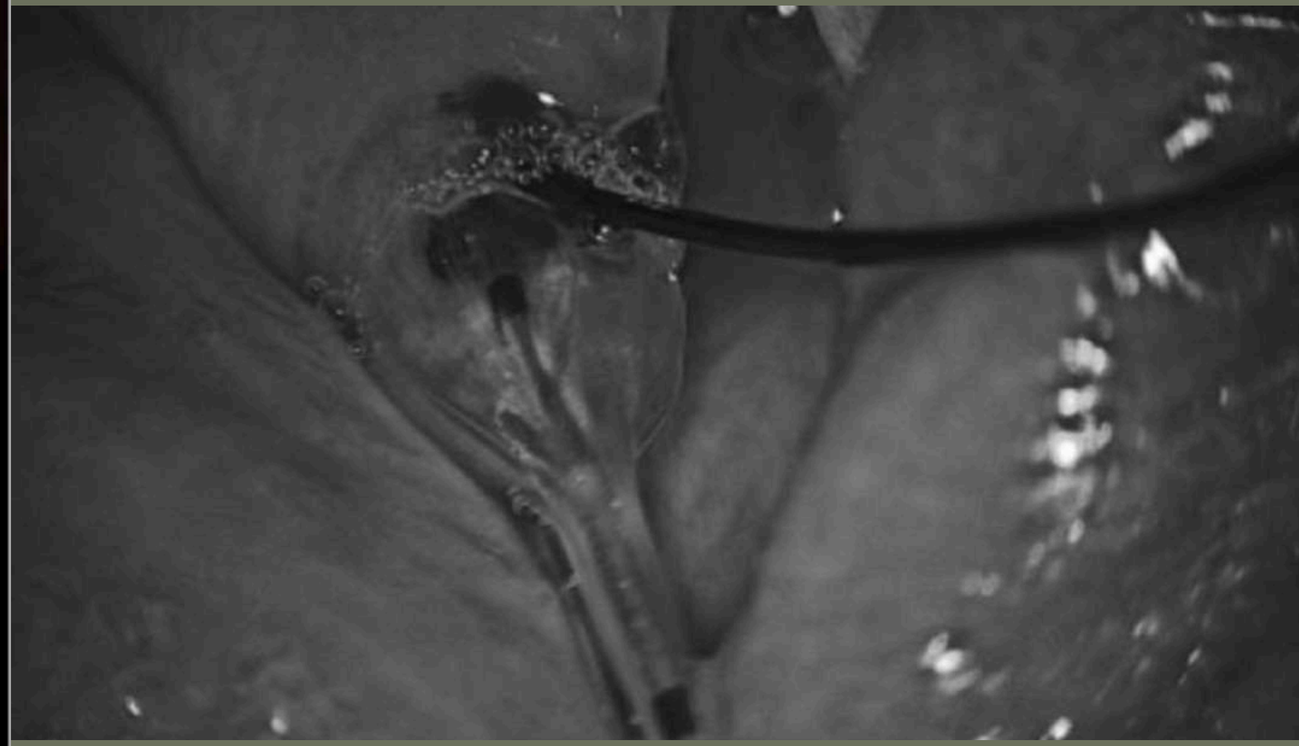
When a person is treated with radioactive iodine to address thyroid gland disease, the salivary glands can take up the radioactive iodine and be damaged by it. In some people, this inflammation - radiosialadenditis - is hard to resolve.

"Patients can experience dry mouth and trouble eating, because the glands don't produce enough saliva. Narrowed ducts can cause stagnation of saliva. Sialendoscopy can dilate ducts and flush out debris, which gives most patients symptomatic relief."

Chronic Salivary Gland Infection Sialendoscopy can also help manage a chronically inflamed salivary gland (sialadenitis) by dilating the ducts and irrigating the gland.

Because sialendoscopy is minimally invasive, there may be less risk of complications than with traditional, open surgery on the salivary gland. However, though rare, sialendoscopy :complications are possible and include Strictures (tightening of the duct) Perforation of the duct Bleeding Ranulas, which are benign cysts filled with saliva.





Balloon dilatation of Wharton's duct.

K-Sialography

- Can be defined as the radiographic demonstration of the major salivary glands by introducing a radiopaque contrast medium into the ductal system.
- Evaluates intrinsic and acquired abnormalities of the ductal system because it provides the clearest visualization of the branching ducts and acinar end-pieces.

The resulting image is called a sialogram.

Sialography has largely been replaced by sialoendoscopy and cross-sectional imaging, such as CT, MRI and ultrasonography.

• It is considered the gold standard technique for studying the ductal morphology. It is commonly used for parotid and submandibular glands and its main indication is chronic sialadenitis unrelated to sialolithiasis.

Irregular pooling of contrast and ductal obstruction without presence of calculus are indirect signs of malignancy.

Sialoaraph is rarelv used for sublinaual imaaina because of numerous

Indications:

- To determine the presence and / or position of calculi or other blockages
- To assess the extent of ductal and glandular destruction secondary to an obstruction.
- To determine the extent of glandular breakdown and as a crude assessment of function in cases of dry mouth.
- To determine the location, size, nature and origin of a swelling or a mass.
- Detection and portrayal of fistulae, diverticula or strictures.
- Detection of residual stone or stones, residual tumor, fistula or stenoses or retention cysts following prior simple lithotomy or other surgical procedures.
- Selection of site for biopsy.

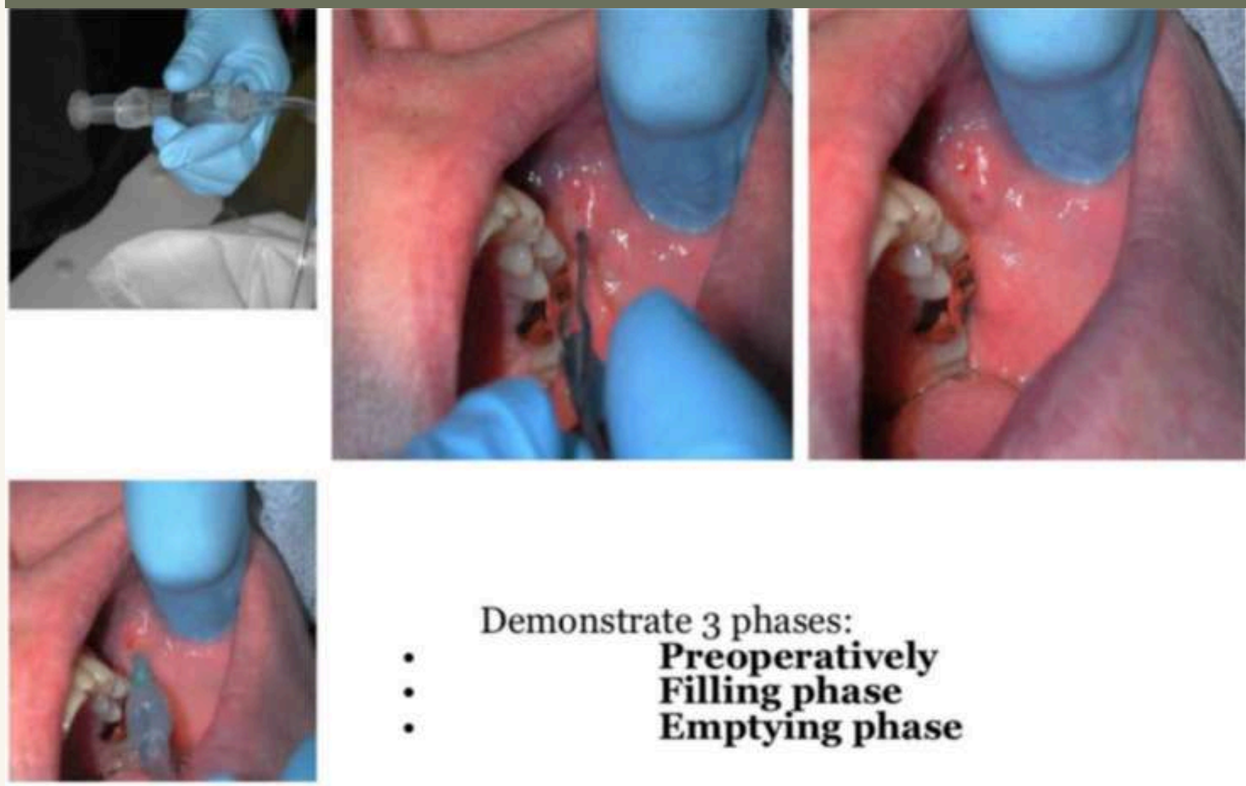
Contraindications

- Allergy to contrast media
- Acute infections of salivary glands
- Patients scheduled to undergo Thyroid functioning tests.

1) Preoperatively - Involves preoperative radiograph for the following reasons:

- Position/ presence of any radiopaque obstruction.
- Position of shadow cast by normal anatomical structures that may overlie the gland such as the hyoid bone.
- To assess the exposure factors.

1. Filling phase- the relevant duct orifice is found, probed & dilated and then cannulated.
2. Then contrast medium is introduced.
3. Emptying phase - the cannula is removed and the pt. is allowed to rinse out. After 1 and 5 mins., the radiographs are taken .



CONTRAST MEDIA

Water soluble (Sinographin Hypaque, Urograffin, Hypaque, Renographin, Renographin, Amipaque, Isopaque Conray, Conray, Omnipaque)

Fat soluble (oil based)

lodised Oils

(Ethiodal, Lipiodal, Lipiodal ultra-fluid)

The three main techniques available for introducing the contrast agent are-

- **simple injection**
- **hydrostatic**
- **continuous pressure - monitored technique.**

Simple injection technique- contrast medium is introduced using gentle hand pressure until the pt. experiences tightness or discomfort in the gland, (0.7ml for parotid and 0.5ml for submandibular gland).

- Advantages- simple & inexpensive
- Disadvantages- can cause damage to the gland

Underfilling or overfilling of the gland.

Hydrostatic technique - aqueous contrast media is allowed to move freely into the gland under the force of gravity until the pt. experiences discomfort.

• Advantages- less likely to cause damage, simple & inexpensive.

Disadvantages- Reliant on pt. responses.

Need to position the pt. in advance for the filling phase radiographs.

Continuous pressure - monitored technique- using aqueous contrast medium, a constant flow rate is adopted and the ductal pressure is monitered throughout the procedure.

Advantages- not likely to cause damage

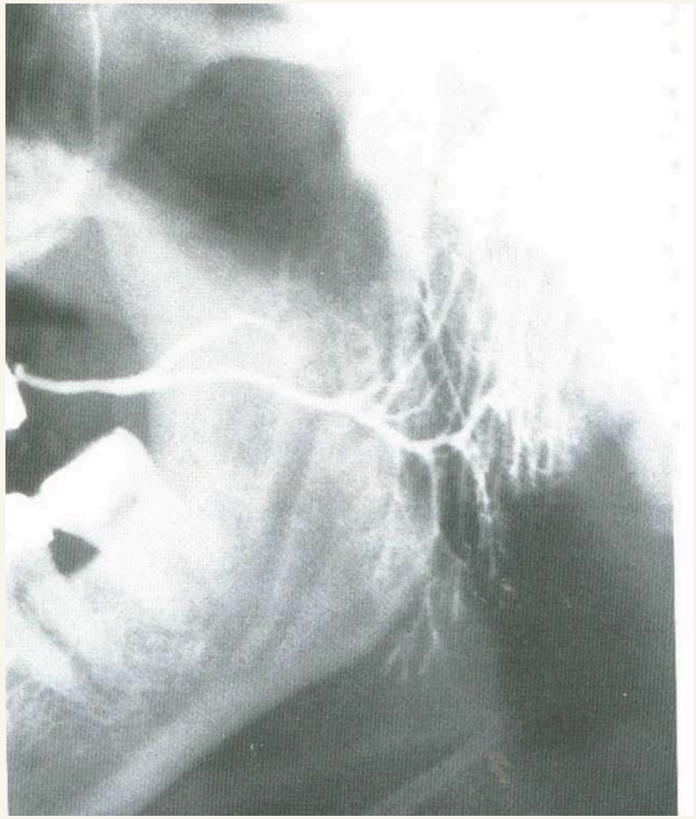
Does not cause overfilling of the gland

Does not rely on pt's response

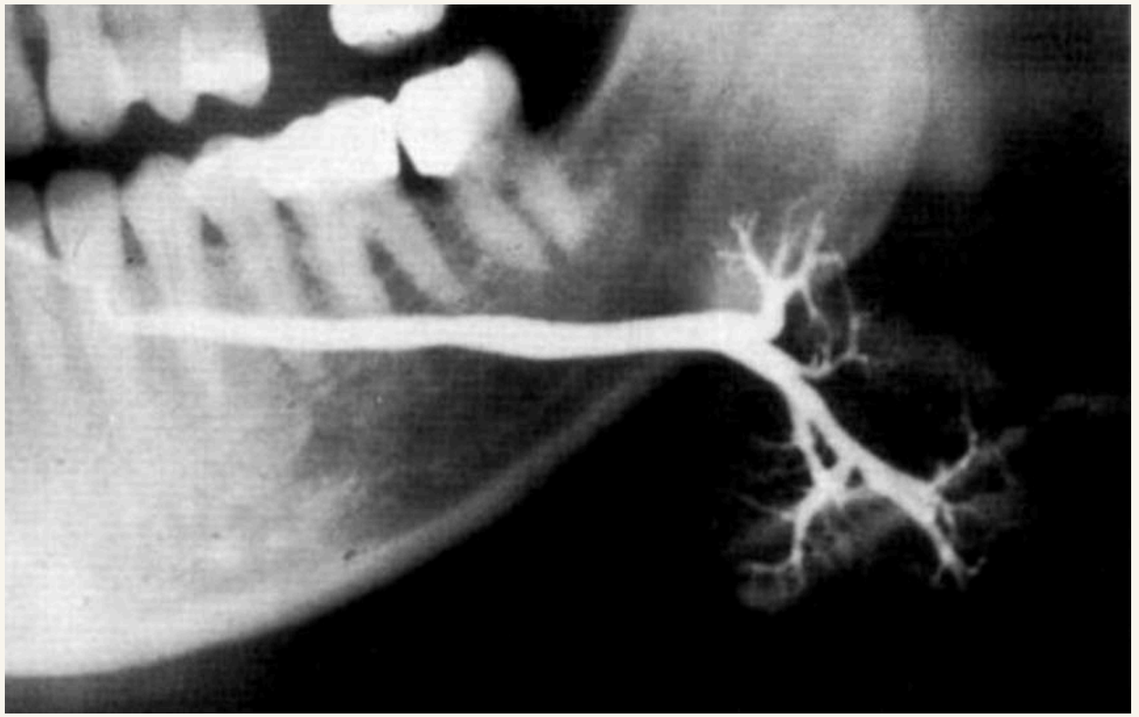
Disadvantages - time consuming & complex equipment

Sialographie appearances

Normal Sialographic appearances and Pathological(Calculi, Sialodochitis, Sialadenit, Sjogren 's syndrome, Intrinsio tumours)



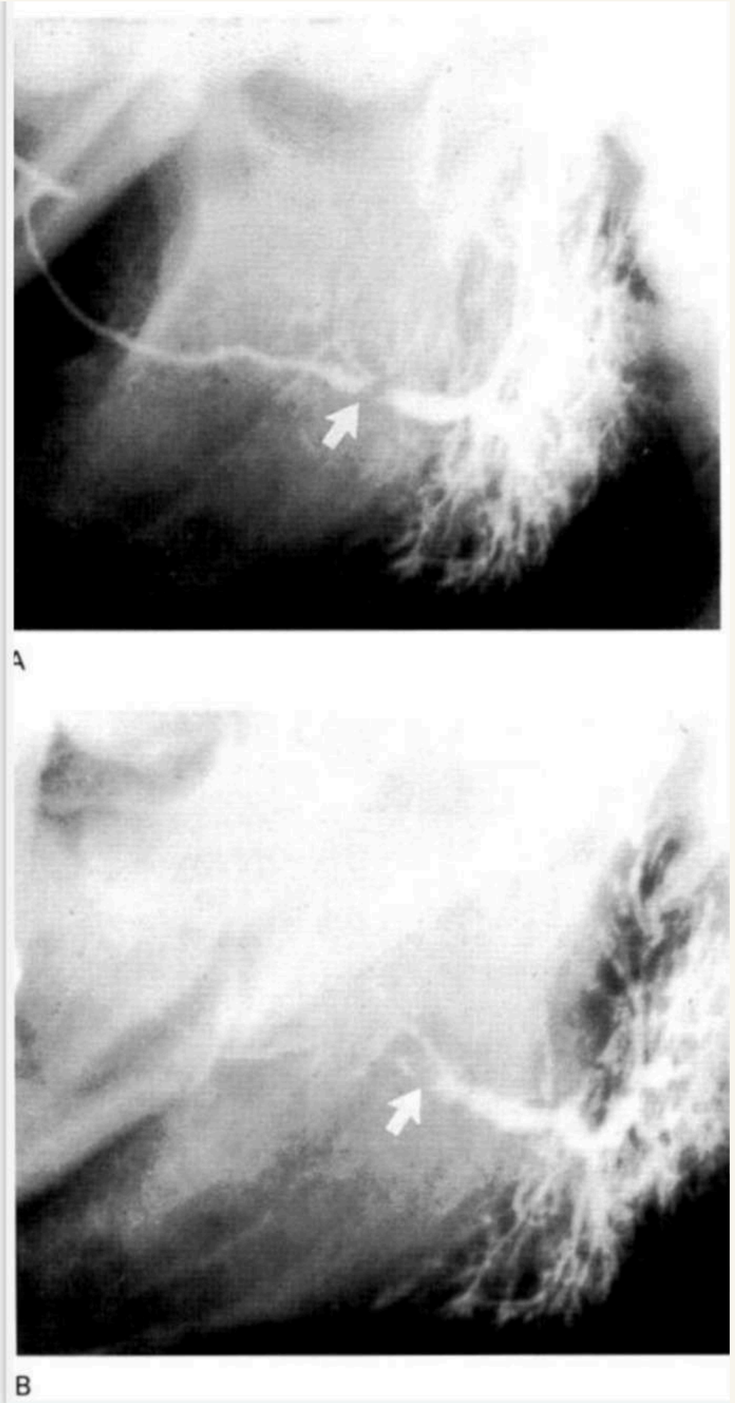
parotid gland
The main duct is of even diameter (1-2 mm wide)
"tree in winter"
"leafless tree" appearance.



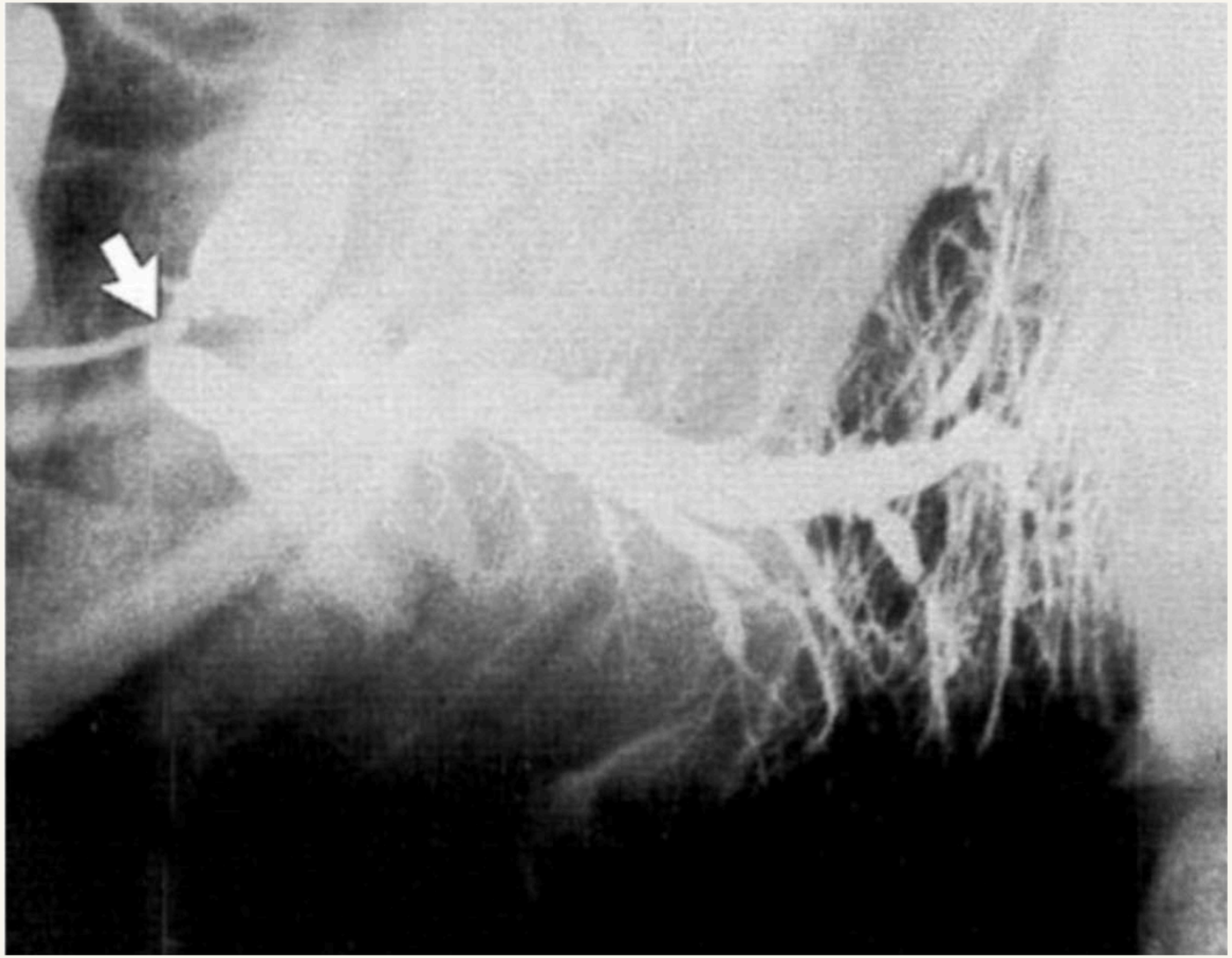
Sialograph showing a normal left submandibular gland, bush in winter appearance

calculi

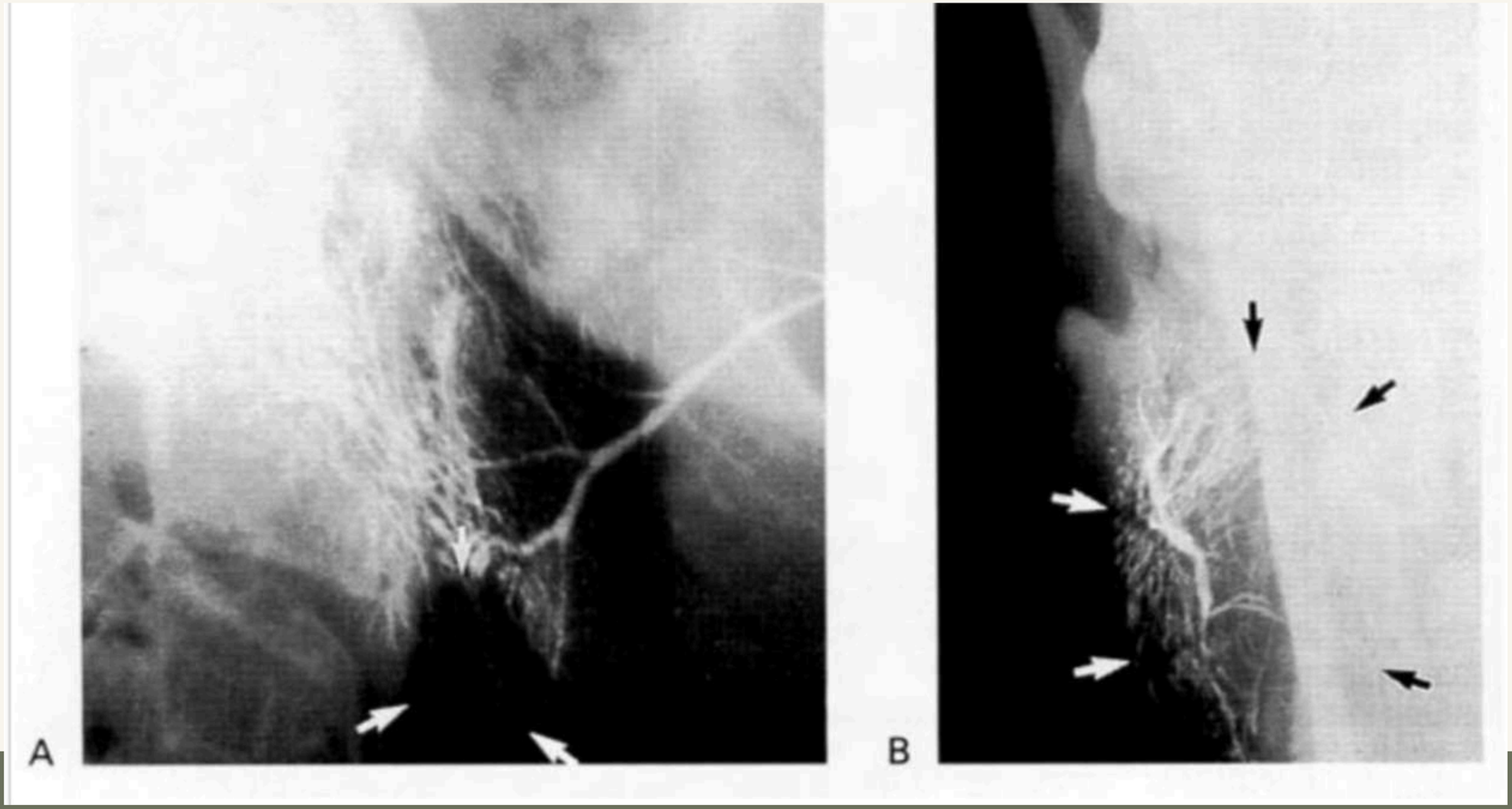
- Filling defects in the main duct.
- Ductal dilatation caused by associated sialodochitis.
- The emptying film usually shows contrast medium retained behind the stone. NORMALY gland EXCRETES 100% DYE WITHIN 5MIN



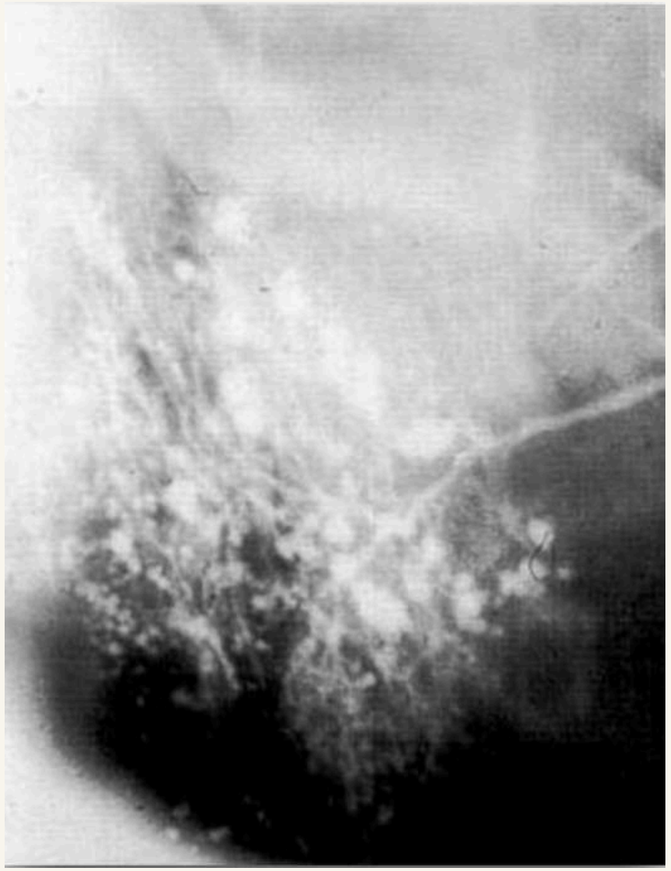
Sialodochitis
submandibular gland, showing a normal main duct, a large calculus (solid arrow) at the posterior end of the main duct and associated segmental sacculation or dilatation and stricture of the ducts beyond the stone. Within the gland (open arrow) the sausage-link appearance is caused by sialodochitis.



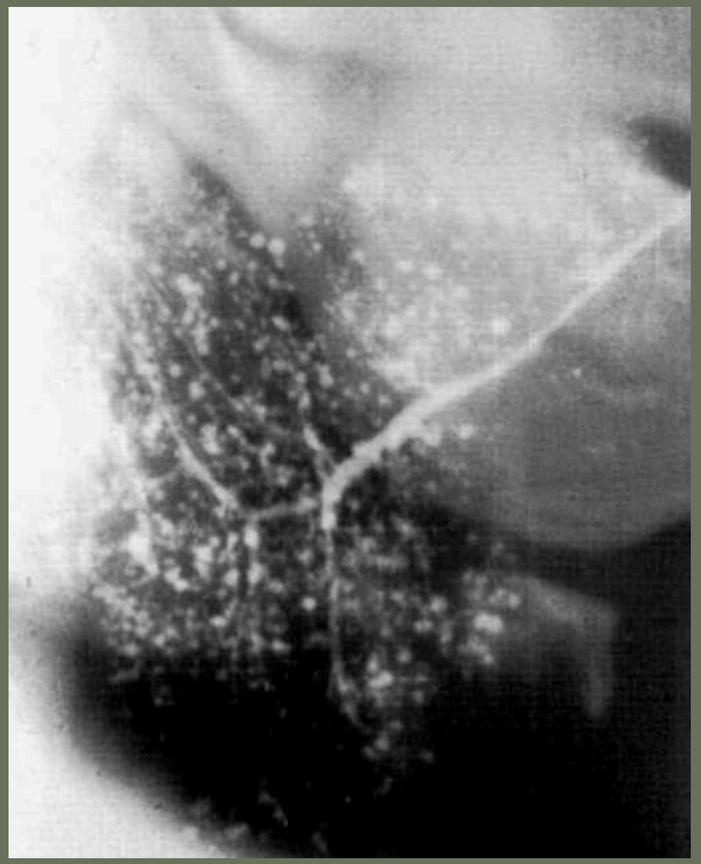
Sialograph of a left parotid showing gross dilatation of the main duct caused by sialodochitis secondary to stenosis at the orifice (arrowed).



A Sialograph of a right parotid gland showing a large area of underfilling in the lower lobe (arrowed) caused by an intrinsic tumour (pleomorphic adenoma). B Rotated AP view showing extensive ductal displacement, the appearance described as ball in hand (arrowed).



Sialadenitis
Sialograph of a right parotid gland showing the dots or blobs of contrast medium within the gland - the appearance known as sialectasis, caused by sialadenitis.
Note the main duct is normal.



Sialograph of a right parotid gland of a patient with Sjogren's syndrome.
The main duct is normal and there are widespread dots or blobs of contrast medium throughout the gland, the snowstorm appearance of punctate sialectasis

- Snowstorm appearance of punctate sialectasis
- Cherry blossom
- Branchless Fruit laden tree

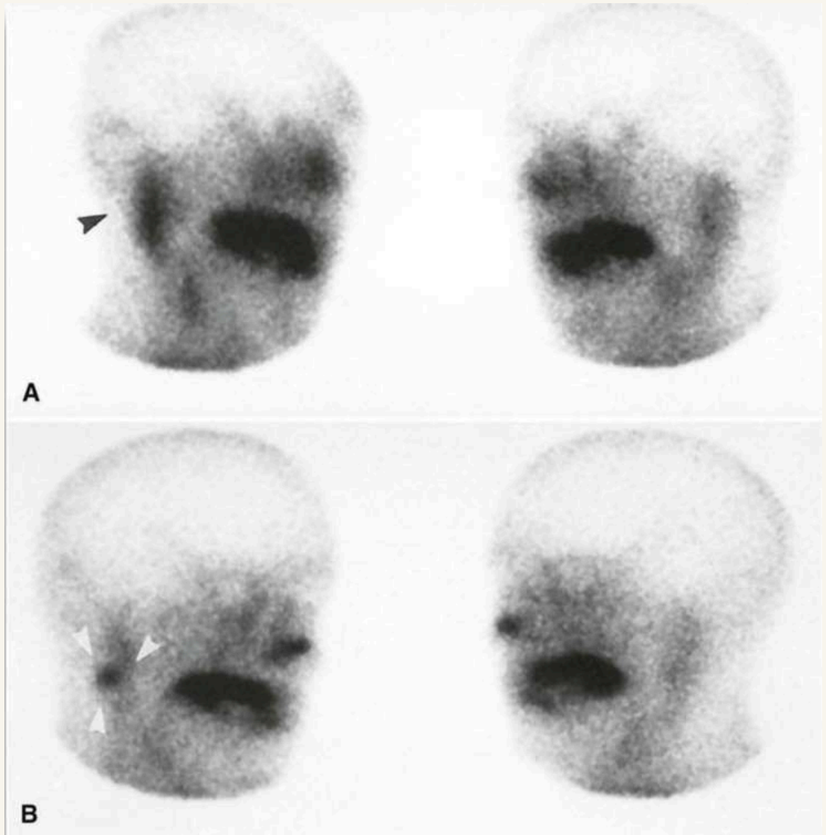
Disadvantages of Sialography:

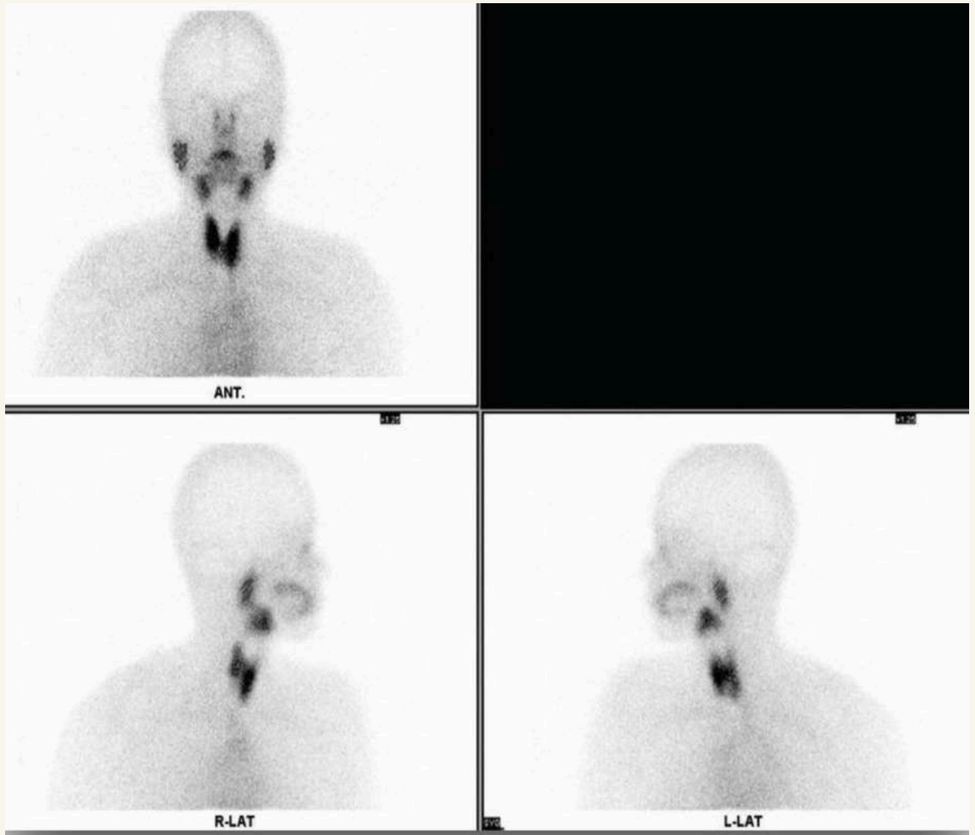
- High skill is needed to conduct the procedure
- Painful procedure
- Possible perforation
- Push stone further

Salivary Gland Function Scan (Parotid Scintigraphy)

A salivary gland scan is a nuclear medicine test that evaluates the function of the salivary glands. These glands include the parotid and submandibular glands, located on both sides of the neck just below the ears and under the jaw. Salivary gland function is assessed by the pattern of uptake and secretion of a radioactive tracer, technetium 99.

Salivary gland scans can help evaluate patients with persistent symptoms of a dry mouth. They are also utilized to evaluate salivary gland swelling due to either infection, inflammation, or obstruction.



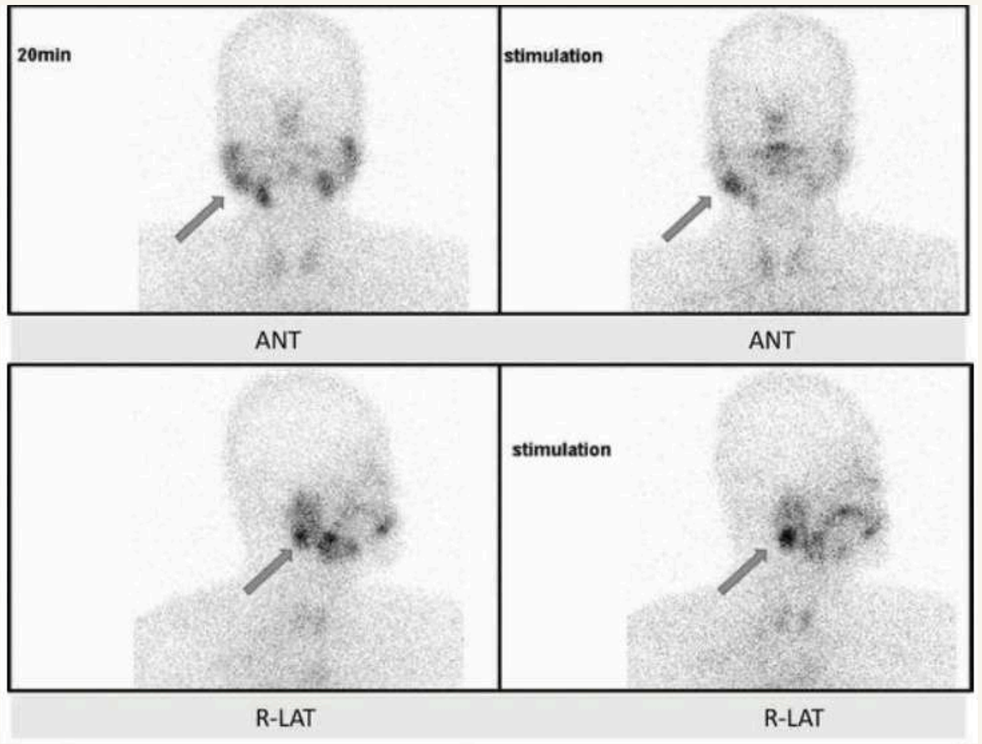


The salivary gland scan, also called parotid gland scintigraphy, is a noninvasive test. It is typically performed in a hospital nuclear medicine department or out-patient radiology facility. You will receive an injection of a low-level radioactive marker and will be positioned in front of or under a gamma scintillation camera, which detects the radiation and produces an image. Imaging typically begins immediately after the injection to observe the progressive accumulation of the radioactive tracer in the glands. After 45 minutes you will be given a lemon drop, or a similarly sour substance, to stimulate the emptying of the salivary glands. Another set of images is then made for comparison purposes. The procedure takes about 60 minutes.

No special preparations are needed for this test. It is not necessary to fast or to restrict medications before testing.

Static images in normal case. The radionuclide uptake of the parotid and submandibular glands is equal to or lower than that of the normal thyroid gland.

20min



Warthin's tumor. On the image 20 minutes after administration, the radionuclide is taken up by the right parotid gland. After the stimulation of saliva secretion, the radionuclide remains in the right parotid tumor.

The diagnosis was Warthin's tumor.

pervious study

Biatek et al., 2003: used US and conducted to estimate the utility of ultrasonography in diagnosis and differentiation of pleomorphic adenomas.in this study, was found from the group of 88 patients examined by ultrasound, who were referred because of the tumor in the pre-auricular area, submandibular area, or cheek, pleomorphic adenoma was finally diagnosed in 24 (with multiple recurrent tumors in 2 patients).

Ultrasound was able to differentiate between benign and malignant lesions with 96% accuracy in this study. Predicting that the detected tumor was pleomorphic adenoma was possible with up to 84% accuracy.

In 15 of 22 patients with primary pleomorphic adenoma, ultrasound guided fine-needle aspiration biopsy.

High-resolution probes and harmonic imaging enabled demonstrationof histopathologic heterogeneity of pleomorphic adenomas (in 16 primary tumors [73%]). Of primary pleomorphic adenomas, 95% (21/22) had 5 or fewer vessels detectable in the whole lesion. They concluded that the Modern ultrasound is highly valuable, useful, and reliable in differential diagnosis of tumors in the preauricular area, submandibular area, and cheek. It enables precise localization, measurements, and assessment of the structure of lesions. It may be the first and last imaging method needed to formulate the final diagnosis, or it may guide fine-needle aspiration biopsy. In many cases, ultrasound may also suggest the nature of the tumor.

(El-Rasheedy et al., 2021) The other study that utilized US and evaluate the role of ultrasound in the evaluation of salivary glands swellings in comparison with a computed tomography scan. In this study A total of 80 patients aged more than 1 year old with swellings affecting the salivary glands were collected from the out-patient clinic during the 23 period from February 2020 to February 2021. All patients underwent ultrasonography and computed tomography examination of the neck. All submandibular gland lesions presented with sialolithiasis (40 cases) (100%), and 20 cases (50%) of parotid gland swellings presented as inflammation without stone (16 cases (40%) of acute inflammation and 4 cases (10%) with recurrent inflammation), while 4 patients only presented as sialolithiasis. Neoplastic lesions were diagnosed in 16 cases of the parotid gland group. Stones less than 3 mm were detected only by computed tomography in 5 patients (12.5%) of the submandibular group.

Twenty-eight cases (70%) with stones ranged in size between 3 and 6 mm.
Only 11 cases (27.5%) with stones ranged in size more than 6 mm.
Of the 16 parotid swellings diagnosed with neoplastic lesions, 14 parotid cases (87%) showed well-defined margins by computed tomography and ultrasonography. They concluded that the Ultrasound is the investigation of choice in salivary gland swellings. Computed tomography could be needed in certain cases such as deep parotid gland lesions or sialolithiasis with small stones in the ducts of the salivary glands.
Computed tomography should be done in cases suspected of malignant salivary gland lesions.

(Oscar Hasson, 2010) was conducted to revisit and reintroduce sialography as an important tool for the assessment and diagnosis of salivary gland obstruction. In this study a sample of 30 consecutive patients undergoing sialography was selected. Parotid sialography was performed in 22 patients (12 females and 10 males). The patients undergoing parotid sialography presented with bilateral or unilateral enlargement or swelling. Submandibular sialography was performed in 8 patients (all males) who had presented with swelling and pain in the affected gland. They found Parotid sialography revealed 6 cases of 24 sialolithiasis without significant duct narrowing, 3 of narrowing and strictures of Stensen's duct without a sialolith, 3 glands with gland sialectasis, 1 parotid gland with intraglandular cyst-like duct degeneration, 1 of a parotid mass displacing Stensen's duct, and 1 gross dilation of duct. The findings of 7 parotid gland sialograms were normal.

Thank you